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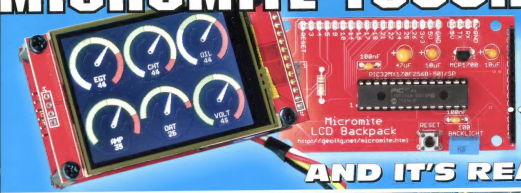

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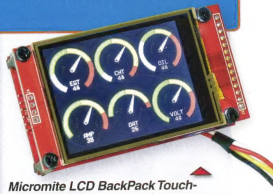

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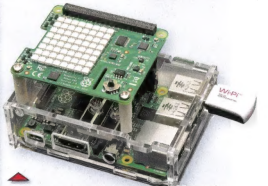

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Publisher's Letter

A defibrillator could save your life or that of your friend

While some readers may find it a little odd that we have a feature article on defibrillators this month, I can assure them that it is a particularly apt topic for SILICON CHIP. In the first place, we have quite a lot of older readers and the longer you live, the more chance there is that you might have a sudden cardiac arrest (SCA). Mind you, young people are also at considerable risk of an SCA if they play strenuous sports or engage in a heavy weight-lifting regimen at their local gym. But sadly, an even more common risk factor for an SCA among people can be if they take drugs, particularly ICE.

However, that is not the main reason why I decided to have this feature produced. In the last few months of 2015, I had tentatively decided that we would purchase one these devices to install in our editorial office. Again, without going into details, some of our own staff are moving into the risk profile (ahem) and you never know. But the pressure of work intervened and we did not proceed.

And then just before Christmas, I was galvanised into action. It so happens that I am a keen ballroom dancer and I do this several times a week. Inevitably, many dancers are fairly senior even though they are often very fit. I am particularly keen on the Viennese Waltz and it is renowned as probably the most strenuous dance. So much so that I have often thought that some of the older dancers should not even attempt to do the Viennese, especially as there is also the risk of a fall while you do it. Having recently had a fall while doing that dance, I know how unpleasant it is. Fortunately, I was not hurt.

However, during a Viennese Waltz at a dance in the following week, someone did fall – and he fell heavily. I immediately knew that this was not good. The dance was stopped and it was found that the fallen dancer was not only unconscious but had no evidence of a pulse. Fortunately, there were a couple of nurses present and they started CPR while an ambulance was called. Several people frantically searched the venue to find if there was a defibrillator available but there was none. So we hoped that the ambulance would arrive with one. But the ambulance took quite a while to arrive and when it did, it did not have one. By this time, I knew that the outcome was unlikely to be good. The man was declared dead about half an hour later.

This caused me serious pangs of guilt because I had recently raised the topic with the organiser of the dance but again, nothing had been done. I shall never know whether a defibrillator would have saved him but I resolved to make sure that if someone does collapse at a dance in the future, there will be a defibrillator on hand.

First, we have purchased a defibrillator for our office and I intend to take it to the dances until such time as the respective venues have their own units. Second, by the time you read this, I will have taken a 2-day first-aid course to bring me up to date; it is many years since I did it. Think about your own activities and consider whether you should also do a first-aid course. It is no burden to have such knowledge and it may save a life in the future.

In the overall scheme of things, defibrillators are not expensive, at typically less than $3000. Every workplace, sporting venue, hotel, club and most local council venues should have them. You can help make this happen.

Leo Simpson

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Source: Distributor Evaluation Study, UBM Tech, May 2015

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MAILBAG

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Reduced power consumption caused mainly by government regulations

Given that the name David Maddison is not particularly common, one is reluctantly forced to assume that your frequent contributor of interesting articles and the writer of the letter in the November 2015 issue, regarding energy production and global warming ('Absurd consequences of green energy', page 14), are one and the same. Given how confused the letter was, I first thought it was a controversy-stirring circulation booster but on reading it more closely I realised that it was serious, or at least trying to be.

Dr Maddison's letter displays such a misunderstanding of electricity supply and electricity economics issues past and present, that it would take a multi-page article to address all its shortcomings.

Dr Maddison sounds like he's been talking to a grumpy long-retired engineer from the State Electricity Commission of Victoria. Sure, the old post-war model of electricity industry growth, where engineers planned additional generation capacity to meet a steady increase in demand, worked well for several decades after World War 2. But times changed, Australia matured beyond its post-war growth phase, Commonwealth-State financial relations evolved, and governments of all persuasions reconsidered their role in the Australian economy. The good old times were good but like the recent minerals boom, the good times never last.

While lamenting the reduction in electricity consumption in 2011, he doesn't actually address why electricity consumption fell. Rather than freezing in the dark due to high prices as he alleges, research indicates that the biggest single factor was the cumulative effect of energy efficiency regulations covering household appliances and new buildings. Restructuring in the economy away from energy-intensive industries such as aluminium smelting was also a factor.

Perhaps it is Dr Maddison's knowledge of economics that is lacking. A good way to remedy this would be by reading the articles of Ross Gittins in the Sydney Morning Herald, starting with www.smh.com.au/business/comment-and-analysis/watts-happening-electricity-demand-falling-as-prices-continue-to-rise-20140822-1072t4.html

If Dr Maddison thinks the scientific evidence on abating global warming is simply defective, I hope he will prepare an article on the subject for a forthcoming issue of SILICON CHIP.

David Menere,
Curtin, ACT.

Comment: regardless of how you analyse electricity demand and cost of production in Australia or anywhere else around the world, there is no doubt that without heavy government subsidies, solar and wind power would not be viable.

Home hybrid solar power systems

I note with great interest the Publisher's hard-headed summary on home hybrid solar systems in the December 2015 issue. This seems to be supported by other readers.

The Publisher's analysis is the same as my conclusion some 20 years ago, in my project paper for a science major "Technology Studies" which was a look at the effect of technology on society past, present and future. My paper also came to a similar conclusion for industrial-scale renewable energy systems that were then currently available (hydro power excepted) and I don't think anything has changed since.

Having been trained in the power generation industry in the UK, I was also very interested in Dr David Maddison's excellent article on the current state of power generation technology in the December 2015 issue. I have enjoyed his series of articles very much and again there were no surprises mentioned since my last study at university in 1996 except the extra complexity in co-generation gas type systems.

David Maddison's article has emphasised why current power generation is so powerful; it produces reliable quality energy in massive quantities continuously and efficiently. This is because of two factors, firstly the energy density/grade of the fuel and secondly the ability of the steam turbine to extract up to 50% of that energy.

The bottom line for the foreseeable future as I see it is rather than install solar panels and off-grid systems, it is probably better to spend money to insulate and improve the passive thermal properties of a building. By going passive first, this will reduce the load characteristic of the house and better match the load to the characteristics of the renewable energy supply.

Kelvin Jones,
Kingston, Tas.

Correction to diagram of coal-fired power station

I enjoyed your very interesting article on Super-Critical and Ultra-Super-Critical Steam Power Stations (SILICON CHIP, December 2015) but I would like to point out an error in the key labelling of the diagram in Fig.2 on page 28.

No. 7 refers to a Boiler Feed Pump but this would in fact be the De-aerator Lift Pump and the Boiler Feed Pump would be the one located between the de-aerator and economiser. The de-aerator must operate at a much lower pressure than the boiler in order to allow out-gassing of undesirable dis-

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Mailbag: continued

Many recent TV sets will not decode MPEG4

On page 11 in the Mailbag pages of the January 2016 issue, Barrie Smith pointed out some issues with the introduction of MPEG4 that will lead to a significant cost for those of us still using older TVs and STBs that don't decode it.

Of my four sets, only two will decode it; a 32-inch Sanyo and my PlayStation 3 and PlayTV tuner. A 42-inch AWA set bought in 2013 will not decode MPEG4; although it indicates h.264, it also reports "Invalid Format". On investigation, this TV appears to be a 2009 model which was still on store shelves four years on. Saying that recent model TVs will decode MPEG 4 is therefore fraught as some retailers are still selling older models.

A 14-inch set, badged Rank Arena, behaves the same way when tuned to MPEG4 channels. The little Rank appears to be more recent, although the distributor cannot be contacted. The 1300 number on the back of the set is disconnected and there is no listing in the White Pages.

Fortunately, I have a small DSE STB and a DVR which both decode MPEG4, so the AWA and Rank can be used on these signals.

A curious point here is that these TVs indicate h.264 as if they support MPEG4 yet also display the "Invalid Format" message. This seems to suggest that MPEG4 support was intended, yet either not fully implemented or the specification has changed since the firmware was developed. Sadly, there is no possibility of a firmware update so the STBs are the only real option.

On a separate topic, in the Vintage Radio article on the Sony TR-63, the author wrote "it also required a new battery design that became the iconic PP9". That should have been "PP3". PP9 was a large block that provided 9V for larger transistor portables. PP3 is a UK/European designation; the same battery used to be known as "216" in Australia.

Incidentally, I'm using the TR-63 circuit to fault-find a 1970s AM car radio, as the PA stage is almost identical. There is gross distortion which appears due to failure of the output pair. Hopefully, a new pair will restore it to full working order.

Wenlock Burton, VK3YWB, Darley, Vic.

solved gases, yet be high enough in pressure and head (height) to prevent boiling of the feed-water in the suction of the Boiler Feed Pumps which would cause destructive cavitation of the pumps.

Dale Sills, Bunbury, WA.

Nine Network HD reception

I'm somewhat bemused with the Nine Network's return to simulcasting their flagship channel in HD in late November 2015. Like just about everybody else, I assumed that they would be simply replacing the GEM feed with a 1080i MPEG2 version of their current 576i MPEG2 "Channel 9" offering. In other words, reverting to the way it was a few years back.

As many readers would know, more than half the HDTVs in Australia can only decode MPEG2! So, imagine my surprise when I tuned my 3-year-old 47-inch LED TV to Ch90 and got nothing, except the blue bar across the bottom the screen saying "9 HD" and "H264" (commonly known as MPEG4), followed by a Black-Screen-of-Death with the terse notice: "Unsupported Format".

Nine's website (as well as a lot of other sites) simply suggests that your TV "might need re-tuning"! Well, no amount of re-tuning is going to insert the amount of processing grunt needed to decode MPEG4 (at least, not in high definition or even standard definition!) if the receiver chipset was never designed for it.

It's not a total loss, because all the set-top boxes I have receive H264 just fine and I'm in the habit of using them instead of the sets' inbuilt tuners anyway, simply because they generally work better and have a much better EPG system (they need to, because they can also record onto USB).

Nobody really loses out, because Ch9 SD is still there the same as before and GEM is now available in SD and it rarely took advantage of the resolution available anyway. (When doing a recording from GEM, the recorded bit-rate was sometimes actually lower than from recording an SD channel!)

But still, what were they thinking? The interesting thing is that the Seven Network also have an H264 service called "Racing.com" on 78. However, *they* didn't give it any publicity at all and even some (horse) racing enthusiasts I know weren't aware of it until I mentioned it.

Keith Walters, Riverstone, NSW.

UPS inverter not suitable for continuous use

With regard to the letter on hybrid solar inverters on page 100 of the December 2015 issue, in the Ask Silicon Chip, I would point out that using an inverter from a standby UPS (rather than an on-line UPS) in this role isn't a good idea. These are designed for occasional operation for brief periods, not long-term use.

Typical standby UPS inverters only have to operate for a few minutes at their full rated power before they've drained the batteries, so they're inherently self-limiting (they'll run longer at lower loads but then they're running at a fraction of their rated power). Running one of these inverters for time periods longer than they're designed for can cause problems, typically due to overheating.

The same comment goes for creating a home-brew extended run-time UPS. By wiring in additional batteries, you would probably be running the inverter somewhat outside its intended parameters.

Peter Gutmann, Bayview, Auckland, NZ.

Daily electricity charges relevant in NZ

The Publisher's Letter in the October 2015 issue expressing (justifiable) outrage over the daily "service" charge has a parallel relevance to NZ electricity consumers, albeit we have legislative separation between the electricity retailer and the electricity distribution

companies – the former collect the daily charge on behalf of the latter.

You would be goggle-eyed to learn what the distribution companies do with their over-the-top "profits" – including investing in wineries, outbidding rivals by paying five(!) times the market price for other electricity assets. Consumers are right to be angry but be as much concerned as to what they're actually doing with the revenue as much as the charge itself.

And as usual, Dr David Maddison has delivered yet another interesting article on computational photography however there was one notable omission, glaringly conspicuous by its absence: the field of spherically projected convex panoramic-image digital photography, popularly used in security video cameras and as a photographic art-form in itself in which the spherically distorted image is "unwrapped" to 2-D in software.

Have a look at the following link as but one example: www.diatrope.com/Stork/Usamietal.pdf

Andre Rousseau,
Papakura, NZ.

Adding FM to an AM radio

With reference to the letter in "Ask Silicon Chip" for January 2016, from reader B. S., wanting information or a project to add FM to his AM receiver, I would like to comment as follows.

In the April 2014 issue of the HRSA magazine "Radio Waves" I described how I added a module from Nostalgic Wireless to my Philips 122 to achieve this result. This is an Australian manufactured product which was designed for converting car radios.

If you can obtain a copy of the article from the HRSA you will see it was particularly easy. My Philips has no external signs of the addition other than a small switch and an extra wire out the back to provide an antenna connection to the FM stage.

At my home, the FM comes in at about the same strength as the AM stations. There may be some antenna issues in the Sydney area but if you can receive FM at your location this add-on will work.

Bob Forbes,
Forest Hill, Vic.

Vintage radio model correction

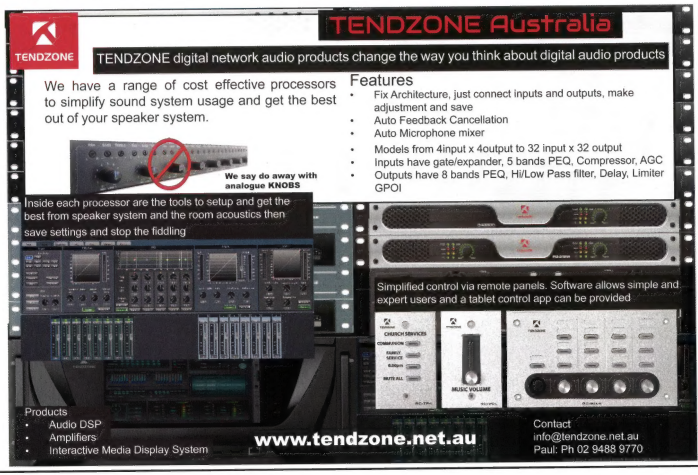
The Fisk Radiola Model 92, featured in the Vintage Radio pages of the October 2015 issue, is in fact a Model 92X. While the valve line-up is the same as the 92, the differences are exactly what the author of the article found when restoring the set.

These differences are the 325Ω cathode resistor and the inclusion of a 25µF electrolytic capacitor between the volume pot wiper & earth. The service manual for the 92X can be found at Kevin Chant's site at www.kevinchant.com/uploads/7/1/0/8/7108231/awa_models_92y_84y_92x_and_84x.pdf

Kent Martin,
West Footscray, Vic.

Military electronics had SMDs in the 1960s

I have just been reading your November 2015 issue of Silicon Chip and a couple of your Mailbag letters caught



Mailbag: continued

In-dash GPS navigation leaves much to be desired

It looks like the humble GPS unit is continuing to cop a fair amount of flak in the Mailbag pages. I would like to put my two cents' worth in, with a gripe about in-built GPS units in cars.

You might think that great big screen in the centre of the dash would be much better than the tiny little Garmin I have sitting above it but that's not necessarily so. The Garmin unit has free updates for life. My Mitsubishi dealer couldn't tell me how much an update of the maps would be but thought in excess of $200 seemed about the industry average.

Surely, a top of the line car would have the maps updated every time it goes in for service. If Garmin and many others can include updates for $150, why can't the car companies do it for a $30,000 plus vehicle? However, that is not the worst of it by a long way.

As with all of these devices, the Mitsubishi unit can be programmed to choose routes with different characteristics. The problem is that once a route has been planned, the Mitsubishi will not deviate from it. If the driver makes a mistake or the prerogative of a human is exercised and the box's instruction is not followed, the stupid thing persists in trying to convince one to return to where the "error" occurred.

I don't know how long it will keep it up because it becomes so annoying that it would get Leo Simpson's removal treatment – except for the hole it would leave in the dash; it has to be turned off.

The little man inside the Garmin simply seems to say, "OK, we're off track here, let's recalculate from here to the boss's destination" and all is well.

My advice is to buy the car you like but if it has GPS, go to the nearest electronics store and spend an extra $150 and get one that might not get you killed or lost.

Graeme Burgin,
Ararat, Vic.

Comment: after-market GPS units have the further advantage that they indicate actual speed; in-dash units are prevented from doing this. And since so many new cars have internet communication, why can't updates be automatic?

my eye. The first is titled "A hot-air rework station is a boon for SMDs", by Mike Flor.

Mike states that he has worked with SMDs since their inception in the late 1970s. In fact, SMD technology was pretty well established in military electronics by then, having started around the mid-to-late 1960s.

I experienced SMDs initially when the RAN introduced the first batch of A4G Skyhawks in 1968. SMDs were extensively used in one of the electronic systems. While it caused us to rethink the repair tools and techniques required, it also turned out that SMD devices were extremely reliable and rarely needed replacing.

My other comment concerns the letter "DIY off-grid solar system", from Robert Hatvani. Robert asks for an article on a design for a system. I hope he does not mean how to design one. I have done some in-depth research on this myself and have discovered that there is a considerable amount of detail on the web already. Much of it at present recommends to not take an off-grid approach as yet, until the battery technology is more advanced.

I would also ask Robert what is his fall-back position with off-grid in the event he has a system or equipment failure?

On a separate but related note, as a recently retired engineer, I am finding the articles and correspondence on renewable energy fascinating and to a large degree frustrating. I find it hard to comprehend the level of ignorance in this country from people who obviously have little or no knowledge of electrical power generation in any of its forms, yet insist on providing uneducated comment.

Unfortunately, they seem to be aided and abetted in this country by many of the renewable industry bodies. Vested interests at work, I guess.

Rod Warner,
Stirling, ACT.

Set-and-forget audio mixer

I noticed in the December 2015 issue of your great magazine, in the "Ask SILICON CHIP" section, that a reader, Y. B., was looking for a simple set-and-forget mixer with preset gain controls for four inputs.

Well, for several years I have, for such a purpose, very successfully used the mixer circuit of mine that you published in the August 2013 issue in the "Circuit Notebook" pages – see www.siliconchip.com.au/Issue/2013/August/Extendable+Mixer+Circuit

In my case, I have five inputs at different levels all into one line input socket, using preset potentiometers at the respective inputs. The circuit shows only one channel, so it needs to be duplicated for stereo. Also, only three inputs are shown but more can be added as described. Perhaps this would be useful for Mr Y. B.

Christopher Ross,
Tuebingen, Germany.

Refining the SiDRADIO

I recently built a SiDRADIO as described in the October 2013 issue of SILICON CHIP. While it all went together very well, initial testing indicated that there were a few problems.

In particular, the voltage from the MC34063 voltage step-up converter was collapsing to less than 10V when the RF gain knob was advanced and there was significant breakthrough of the 80-odd kHz switching of the voltage step-up converter, leading to spurious peaks in the spectrum either side of the actual one (this being a serious problem on the lower frequency bands). Finally, the front-end coils were not covering the specified tuning ranges.

The first of these was due to the fact that the BF998 FET draws over 10mA as the voltage on its G2 is increased and the MC34063 step-up converter was current limiting at about 6mA. This current limit is set by the 4.7Ω resistor connected between pins 6

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Mailbag: continued

Air-conditioning stand-by power can be excessive

My wife and I purchased two inverter split system reverse cycle air-conditioners, one about three years ago and the other a year ago. Dale Silver, a contributor to the magazine "Renew", pointed out that these air-conditioners, although efficient when actually operating, draw considerable standby current when switched off using the remote control.

I decided to check the standby current of our air-conditioners, a 7.1/8kW cooling/heating unit and a 2.5/3.2kW cooling/heating unit. The larger unit draws around 190W and the smaller around 60W, on a summer day with temperatures in the high 20s. I checked this by using a current clamp meter and a direct inline amp meter (RMS reading) so that I had a reasonably accurate figure.

This standby power usage equates to around 6kWh per day. It is claimed that the power is used to heat the compressor oil but surely with temperatures around the high 20s, this is not required. The units are from two different mainstream manufacturers and Dale Silver's air-conditioner is from another manufacturer, so it is endemic with this type of air-conditioner.

Surely this is not the way to go when we are urged to reduce our use of resources? Plus, it is costing thousands of users many hundreds of dollars and in our case, some $700 for a year's worth of standby power. Most electronic devices these days draw under a watt of standby power. I wonder what the manufacturers have to say?

Rodney Champness, Mooroopna, Vic.

Comment: while very low standby power should be a requirement for all air-conditioners, it should be possible to turn them off completely with a separate switch. This is desirable both to avoid high standing charges and also to enable isolation during thunderstorms. This is doubly important with 3-phase air-conditioners since their motors can be damaged if one mains phase is lost.

& 7. Decreasing it to 2.2Ω solved the problem.

The breakthrough of the 80kHz switching of the voltage step-up converter took a little longer to track down. Having eliminated any ripple on the 12.5V as a possible cause, it turned out to be mainly due to the ripple it was causing on the 5V line and also some coupling into the RF circuits via the earths.

The ripple was all but eliminated by inserting a filter between the 5V line and the input of the MC34063. The filter comprised a 500µH choke wound on a toroid (same as used in L5) followed by a 100µF 16v electrolytic in parallel with a 1µF chip capacitor. These were placed right at the MC34063 as shown in the attached photo, the short trace between the on-board 1µF chip capacitor and the 4.7Ω (now 2.2Ω) resistor having been severed.

It also took a bit of trial and error to minimise the coupling through the earths but a solution was finally found by isolating the voltage step-up converter circuitry from the main earth plane, by cutting the earth plane copper on both sides of the circuit board as also shown in the photo. This leaves just a single earth connection via the thin copper trace that runs alongside the dongle and reduced the spurious peaks in the spectrum down into the noise level.

This left just the front end-tuning problem. While I wound all the coils in accordance with the instructions in the SILICON CHIP article, I found their measured inductances for all except L4 to be a long way from those indicated on the circuit diagram, thus causing the tuning problem. After rewinding L1, L2 & L3, I managed to get nearly contiguous frequency coverage from 280kHz to 24MHz but well short of the 100kHz – 35MHz claimed in the article.

The reason for this is as follows. In isolation, C1 had a minimum capacitance of about 5pF per section (trimmer plates fully out) but when in the circuit, this rose to about 25pF in total (with the link to S2b disconnected). This increase was due to the various traces on the circuit board and the small capacitance of G1 of the BF998 FET. This severely limited the tuning range available from C1 at high frequencies, necessitating a compression of the overall tuning range.

With all these changes, the converter now works very well considering its fairly simple design and lack of comprehensive filtering at the RF input,

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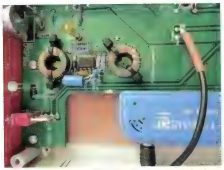

Above: the modified PCB and added circuitry inside the SiDRADIO.

at the output of the 125MHz oscillator and between the converter circuit and dongle.

I suppose one might ask why bother to build it at all when true communications-grade HF up-converters are available at no greater cost (eg, the NooElec Ham It Up converter available from a number of sources for around $55). For me the answer is in the pleasure of building things and tweaking them for maximum performance. To this end, SILICON CHIP provides an incredible resource. Long may it continue!

Finally, some links on the topic that I found interesting:

Active antennas:

(1) www.g8jnj.net/activeantennas.htm

(2) http://dl1dbc.net/SAQ/Mwhip/Article_pa0rdt-Mini-Whip_English.pdf

(3) www.ebay.com/itm/Mini-Whip-active-antenna-kit

Up Converters & shortwave:

(1) http://retrovoltage.com/2012/09/14/round-up-of-rtlsdr-upconverter-choices/

(2) www.short-wave.info/index.php

Paul Rossiter,
Applecross, WA.

Lundahl transformer caption correction

Thank you very much for the nice review article about Lundahl Transformers on pages 46 & 47 in the December 2015 issue. As a small company based in Sweden, we are very pleased to read an article about us published in the Antipodes.

We would, however, like to make a small correction regarding transformer core types. In the text underneath a picture on page 47, C-cores are mentioned. But the picture actually shows how laminations are inserted in a mu-metal lamination core.

For our small audio transformers we use three different core types. Silicon-iron C-cores (manufactured in house) are mostly used in line output transformers. Uncut amorphous cores (as in the cut-away picture) are used in input and video transformers. Mu-metal lamination cores are the most commonly used cores in pro audio types, such as microphone transformers and in transformers for splitting and for line input.

If in doubt regarding which core type or transformer type to choose for your project, please do not hesitate to contact CDA Pro Audio (www.cda-proaudio.com) for support.

Per Lundahl Norrtälje,
Sweden.

Request for a digital audio player project

The so-called "MP3" player has almost completely died out in favour of smart-phones but there now seems to be a resurgence of stand-alone audio players or DAPs at the high end of the market, from companies like FIIO, iBasso, Cayin, HiFiMan, Sony etc, starting at around the $500 mark and going up to, frankly, quite ridiculous prices in the many thousands.

These players aim to appeal to hifi enthusiasts and so called "audiophiles", with up to 192kHz/24bit decoding, very low distortion etc.

I was going to suggest a SILICON CHIP DAP – an entire player – as a project. But on reflection, it seems to me that the software to control the device would be far too time-consuming and expensive for you to develop in-house. There is complete DAP open-source software available from Rockbox (www.rockbox.org) that runs on ARM processors but this would have to be adapted to run on any specific device, and even that is likely to be a time-consuming and expensive process. Still it would be wonderful to one day be able to build a SILICON CHIP DAP. I'll keep my fingers crossed!

However, most of these high-end DAPs feature digital outputs of the SPDIF variety, to allow connection to portable lithium battery-powered DAC/headphone amplifiers which these high-end DAP companies also sell.

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SKU: SPE-075
Price: $179 ea + GST

IP65 Multi-Level Signal Tower
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ESP8266 Dev-Board
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SKU: SFC-035
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Mailbag: continued

LED lamp reliability question

Like most people today, when a domestic lighting lamp fails, I replace it with a modern type, the choice being between a compact fluorescent (CFL) or LED unit.

Frankly, a CFL is a half-hearted change but it does have the virtue of being a simple plug-in replacement without an intervening transformer, so I was tempted. Then I saw in one store some traditionally-shaped bulbs claiming to be LED and boasting nominal long lives, such as 35,000 hours. Sounds good I thought but the rest of this story is based on two examples that seriously let down the side:

(1) a 6W Energy/35W/400 Lumens/ Light 2700K lasted eight months or about 1440 hours use; and

(2) a 10W Energy/60W/806 Lumens/ Light 2800K lasted 28 months or about 5000 hours.

In both, the intended power source is (as labelled) 220-240V/50Hz. I won't name the brand but both are from the same Chinese manufacturer.

The bulbs were not in vacuum and the things came apart easily after cracking same. In both cases, the failure was in the SMPS part of the device, ie, no output voltage to the LEDs. I did not pursue the cause of the SMPS failure because the only salvageable part was the LED assembly. I did however note the rating of the electrolytic capacitor across the output which was 50V.

In the first unit, there were 12 LEDs mounted on a 2mm thick aluminium disc of 40mm diameter. With only two leads emerging from it, it took only moments to connect the bench DC power supply and crank it up slowly, to be rewarded by a bright glow.

There was no current drawn at voltages below 15.5V but at 15.8V, it drew 10mA (about 1.32V/per LED); at 16.15V it was 27.5mA and at 17.4V 80mA (about 1.45V/per LED). At this point I decided that, heatsink or no, I needed to determine what current the manufacturer intended it to run at.

Since a minimum of nearly 16V was required to cause current to flow, there seems little doubt that the 12 LEDs are simply strung in series. As you would expect, the brightness increased in step with the voltage/ current increase but I had no way of measuring the effective Lumens, so I tried to reason it out as follows:

Since the labelling claims 6W @ 240VAC, then 6 ÷ 240VAC must be in the ball-park, ie, around 25mA . This sounds reasonable but it made me wonder how the other lamp achieved its higher rating. The second unit turned out to have 20 LEDs on an identical aluminium disc to that of the 12-LED unit, supplied from a similar 50V electrolytic capacitor. In this case, there was no current drawn below 24V and at 25.4V it drew 10mA (about 1.27V per LED); at 25.8V it drew 25mA and at 27.1V it drew 80mA (about 1.36V per LED).

Applying the same calculation as above to estimate the intended current in this unit gives 10 ÷ 240 = 42mA. To my eyes, the LEDs seem identical in both units, so it seems

the higher-rated unit not only has more LEDs involved but they are also run harder.

In short, I suggest that these components might be worth scavenging. True, the required voltages are a bit outside the range of the most frequently "disposed of by the roadside" plugpacks. However, I unearthed from my stock a 32V 1.2A supply from just such a source. For the 20-LED unit, this requires only a 270Ω series resistor to drop 6.8V @ 25mA. The wasted power is a mere 169mW (<0.2W).

Brian Critchley,
Elanora, NSW.

SILICON CHIP has already produced several high-end DAC projects, so I wondered about the possibility of a SILICON CHIP portable DAC/headphone amplifier project. I envisage it as having the emphasis on very high quality sound rather than portability, so keeping it down to a very small or light form factor would not be a high priority.

Many of these high-end DAPs are quite large and relatively heavy, and clearly people who value very high sound quality are prepared to make sacrifices in terms of size and weight. It would have a copper SPDIF input and a standard headphone jack output or perhaps two, and a DC input socket for charging.

Apart from an on-off switch, I imagine that's all that's needed. There would be no need for any kind of display, although it might be nice to have a couple of LEDs to indicate the nature of the input signal, eg, the sample rate and bit depth. It would also be nice if the project allowed the use of a commonly-available standard lithium battery size, such as one of the standardised circular cells (18650) as used in the Pono Player, allowing batteries to be replaced without having to throw the entire device in the bin, as seems common with all the commercially-available devices.

Phil Taylor,
Casula, NSW. SC

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BCA138256WR	6V / 12V	3.8A	+	+	+		IP65	+	+		
BCA1702WR	12V	7.0A	+	+	+	+	IP65			+	+
BCA1123	12V	12.0A	+	+	+	+	IP20			+	+
BCA2602	24V	6.0A	+	+	+		IP20			+	

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Defibrillators Save Lives

Photo courtesy First Aid Plus

CPR has long been considered the most important first-aid skill you could learn. Arguably it still is – but using an Automated External Defibrillator (AED), is becoming just as important. It can save many more lives!

by Ross Tester

If we told you that performing CPR (Cardio-Pulmonary Resuscitation, or heart-lung resuscitation) on someone who has suffered sudden cardiac arrest, (SCA) is **successful in only about 5-7%** of cases, you'd probably be surprised.

But you'd probably be even more surprised to learn that adding a defibrillator and CPR training shoots that success rate **up to around 60%** (some authorities say even higher).

The reason is pretty simple: an SCA usually (though not always) doesn't just stop the heart pumping blood, often it "scrambles" the electrical signals in the heart so that it does not rhythmically beat, even if it wants to (and it does – the heart really wants to start rhythmically beating again). An ECG of someone who has effectively died perhaps half an hour before will sometimes show tiny pulses, albeit too small to be of any use, as the heart valiantly tries to get going again).

What happens is that the confused electrical signals send the heart into *ventricular fibrillation*, where it simply "quivers" rather than pumping blood through its four chambers. Little or no vital oxygen-rich blood gets to the heart and brain and within a few minutes, the cells become damaged. A few min-

Why publish this in SILICON CHIP?

If you're wondering why we have published this feature in what is primarily an electronics magazine, it's for three very good reasons.

(1) Medical Electronics is a fascinating field that not too many know about.

Most readers would have heard of defibrillators but we believe that relatively few would know what they are actually used for (apart from the "Packer Whacker" mentioned elsewhere), how they're used or their limitations. Indeed, most readers' experience would be the totally false movie and TV show images of a doctor looking at a flat line on an ECG monitor, yelling "clear" and delivering a shock which makes the patient almost jump off the bed!

As you read this story, you will begin to understand that defibrillators are highly sophisticated devices which these days do far more than shock someone back to life after a heart attack (which, by the way, they virtually never do unless that is followed by SCA or sudden cardiac arrest!).

2: SILICON CHIP readership is overwhelmingy those who just might need a defibrillator . . .

Whether they are in the position of first-on-the-scene after someone has suffered a SCA or they are the person needing one, we hope that this feature might open a few eyes to the appropriate use of AEDs, now that they are to be found in many public buildings, offices and so on.

3: This is arguably the most important reason!

We hope that this article might encourage business owners and managers to buy a defibrillator for their workplace (just as we have now done at SILICON CHIP).

We list several defibrillators on page 19 – there are many more.

Today's Public-Access AEDs are designed for totally novice and untrained use – they tell you what to do and how to do it. Most are relatively inexpensive these days (and tax deductible).

Just imagine how you would feel if someone in your office/factory/etc died because you hadn't taken that simple step.

utes more and the damage becomes permanent and death follows not long after.

The experts tell us that the first three to five minutes are vital – that's how long we have before damage starts to occur. After ten minutes, assuming the victim isn't also suffering from hypothermia, or reduced temperature, permanent damage is done. Hypothermia slows down the damage but damage is still inevitable in time.

What's wrong with CPR?

Absolutely nothing . . . everyone should learn it. CPR is vital in the link to a successful resuscitation outcome, providing oxygenated blood to the heart and brain. CPR simply keeps the blood flowing where the heart isn't functioning or not functioning properly.

The actions of the first aider repeatedly and rapidly pushing down on the chest forces blood through the lungs

Doing it (almost!) for real: Manly Life Saving Club members Max Moon and Jonathan Curulli, under the watchful eye of assessor Joe Mastrangelo, undertaking their AED qualification, part of Surf Life Saving's Advanced Resuscitation Techniques Certificate. The difference between this and the real thing is they're using a "trainer" AED, obviously on a dummy!

"Heart Attack" (MI; Myocardial Infarction) vs SCA (Sudden Cardiac Arrest)

A Sudden Cardiac Arrest (SCA), which can be defibrillated, is quite different to a "heart attack", more properly known as a Myocardial Infarction (MI), which can't.

Think of SCA as an "electrical problem" and MI as a "plumbing problem". SCA prevents the heart from beating due to its electrical signals being scrambled, while MI is something physical (for example a blood clot or other blockage) in the arteries which prevents blood flow to the heart itself.

The heart is a complex of nerves and muscles in their own right; an MI will usually cause nerve and muscle damage when they are starved of oxygen but will not necessarily be fatal if treated within a reasonable time. Hence MI patients receive "bypasses" and "stents" to allow blood to flow around or through a blocked area.

On the other hand an SCA if not treated immediately (<5 minutes) will almost always be fatal .

An MI may in some cases may trigger an SCA but this is not usual.

As far as the first-aider is concerned, CPR, (preferably with a defibrillator) is the only immediate means of treating an SCA, whereas the usual treatment for MI is to sit the patient up and call for medical help.

CPR must never be performed on a conscious (ie, MI) patient; indeed modern defibs will not allow you to administer a shock if it detects that a true pulse is present.

In all cases, MI or SCA, medical help should be summoned immediately. If you are by yourself, do not stop CPR but yell out until someone else is able to help

(to pick up oxygen) and to the heart and brain (especially), along with the other organs of the body.

There are two problems with this: first of all, CPR is incredibly tiring for the person administering it; so much so that the average person is lucky to effectively compress the heart for two minutes. When you train in CPR, you train to be able to swap with new people to keep going.

The rule for administering CPR is that it should be continued for as long as the first aider(s) is/are physically able to continue, or until medical assistance arrives. Victims have been reported to have recovered after more than an hour of CPR – just so long as it is continued with no pauses.

Indeed, the record (for someone also suffering severe hypothermia [low body temperature]) is a whopping six hours, 30 minutes. Hypothermia appears to slow down the onset of brain and other tissue damage.

(The opposite is also true, by the way – someone who is overheated [hyperthermia] will tend to suffer organ damage faster than someone who is cool.)

Good CPR is the only effective method of changing "fine VF" (flatline) to "coarse VF", which is a shockable rhythm.

However CPR will not stop VF – the quivering heart needs an electrical shock to effectively stop the scrambling, so that it can start it beating again in a "sinus" rhythm.

Enter the defibrillator

Believe it or not, the defibrillator's job is to stop the heart. It supplies a large shock current, directly across the heart, to "freeze" the muscles and so stop it fibrillating. Then, the heart may start beating properly of its own accord.

Even if it doesn't, continuing CPR once the heart is no longer fibrillating gives the victim the best chance of survival.

Recent medical research suggests that the first shock is the most important. Until now, most defibs "ramp up" the shock in the belief that higher charges may damage the heart. However, some manufacturers have now switched over to delivering a large shock first up.

How much charge?

This depends a lot on the manufacturer and how their waveform is set up. This, in turn, is determined by several factors, not the least being the impedance between the pads (ie, across the heart).

Early AEDs used a "monophasic" waveform – one where the current went in one direction only. The recommended charge for these was 360J for adult patients (Joules = voltage x current x time). The charge was delivered in a very short time – a couple of milliseconds or so – meaning that the other components, voltage and cur-

A defibrillator "Trainer", such as being used in the photo overleaf, looks and works like a "proper" defib – except for the vital detail that it cannot supply the shock. The trainer gives the same prompts as a real AED, including the spoken instructions. It is clearly labelled as a training device and the pads (also labelled as training electrodes) can be used over and over, unlike the real thing. This trainer is from Cardiac Science. At right is the real defibrillator – notice the difference? Apart from not having the "Trainer" and "Not for Human Use" labels, there isn't one you can see.

rent, were rather high. Most worked on a voltage between about 500V and 2000V DC.

Further research showed that a "biphasic" waveform, where the current travelled in both directions, was just as effective but with simpler circuitry, smaller battery and lower weight. These days, the vast majority of AEDs which you come across will be biphasic.

The advantage of biphasic waveforms is that the current can be lower than monophasic, resulting in less potential damage to the heart. And with lower power, there are fewer burns and lower battery use. Not only that, the first shock success rate of a biphasic machine is claimed to increase from 60% to 90%.

A typical AED might deliver 200 (or more) joules, with a current of perhaps 30A or so delivered over 10ms.

The AED also analyses the "dryness" of the skin. With drowning victims, the first aider is taught to dry the skin before applying the pads. This is to both help the pads "stick" and increase the impedance, so the AED can operate more efficiently.

There is a shock hazard when the shock is delivered, so the first aider is also taught to ensure that no-one is in contact with the victim (his/herself included!).

Note that manufacturers arrange delivery of their charges differently so comparing one with another is not practical nor accurate – none has been demonstrated to be superior to another.

How do they work?

Public-access defibrillators (ie, those mounted in public areas and designed to be available to anyone, even untrained) all give specific, clear instructions, including where and how to place the pads. Apart from infants, the location is almost invariably on the upper right chest and the lower left side – this gives the best possible path through the heart.

Infants usually have the pads placed front and back over the heart.

Pacemakers and implanted defibs?

While it is quite possible that an external defibrillator will "fry" the electronics in an implanted pacemaker or defibrillator, the experts all say to ignore them.

If the victim is in ventricular fibrillation (VF), it's obvious that an implanted defib is not doing its job. And a pacemaker can't work in VF anyway . . . the alternative is to let the victim die.

Here's the procedure

If you've done a first aid course, you'll remember the mnenonic

DRS ABCD

You may also remember that this stands for **Danger, Response, Send for Help, Airway, Breathing, Circulation** and **Defibrillation.**

Mr Bean's Defibrillator

You ***must*** have seen that episode of "Mr Bean" where Rowan Atkinson attempts to deliver resuscitation to a man in the street using a pair of jumper leads connected to a power pole.

Is it art imitates life or life imitates art? We're not sure, but this has *some* (OK, miniscule!) factual historical basis: early defibrillators (in hospital operating theatres) actually used 300-1000V AC derived from a step-up transformer connected to the mains, with research funded by the Edison Power Company!

The first successful use on a human (a 14-year-old boy being operated on for a congenital chest defect) was in 1947 by Claude Beck, professor of surgery at Case Western Reserve University in Cleveland, Ohio. The boy's chest was surgically opened and manual cardiac massage was undertaken for 45 minutes before the defibrillator arrived. Beck used paddles on either side of the heart.

Closed-chest defibrillation, using 100-150ms shocks @ >1000V AC, was pioneered in the USSR in the mid-1950s, while portable defibrillators were first used in the late 1950s and early 1960s.

Today's defibrillators deliver a very much shorter shock.

By the way, you can see the episode of "Mr Bean Rides Again" on https://www.youtube.com/watch?v=0wXQE5kh2SE

The "Packer Whacker"

25 years ago, media tycoon Kerry Packer suffered an SCA while playing polo – and the one ambulance in NSW which had a defibrillator on board happened to be the one which was standing by for any injuries during the polo match.

Packer was revived using that defibrillator and he subsequently donated enough money to the NSW Ambulance Service to equip every ambulance with a defibrillator. These earned the nickname "Packer Whackers" after their famous benefactor.

Packer died on Boxing Day, 2005, not from heart disease but from kidney failure.

The very latest teaching is much simplified and reflects the expert guidance that heart compressions are all-important to keep the blood flowing; much more so than the older routine, which experience has shown that most people, even trained first-aiders, can get wrong in the panic of a "real" emergency.

But before anything else, as with all first aid, you need to get someone reliable to call for medical help (ie, an ambulance).

The latest mnenonic, at least overseas (but could change here) is simply

CAB

This stands for **Compressions, Airway and Breathing**.

This calls for compressions to be commenced as soon as no "signs of life" are detected. These signs have also been simplified – you no longer have to feel for a pulse (that's the main thing lay people got wrong) but simply establish that the victim is both unconscious and is not breathing.

Of course, you still need to ensure the victim (and you!) are in no danger and that the airway is clear but it is now considered imperative to start compressions as soon as possible – ie, immediately!

While you're doing this, have someone else set up the defibrillator.

The routine is:

1: Turn on the defibrillator – it will go through a self-checking routine and tell you when it's ready to go (usually only 5-10 seconds).

2: Attach the pads to the patient, where shown by diagrams on the defibrillator.

You will almost certainly need to remove upper body clothing, wetsuits, (most defibs contain a pair of scissors to make this as quick as possible). If the victim is a man with a very hairy chest, use the shaver provided to remove hair under the pad positions. If the victim is a female with an underwire bra, this should also be removed to eliminate any short circuit possibility.

Two models of AED from the same company, the HeartOn A10 on the left and the A15 on the right. The main difference is that the A15 caters for both adult and child defibrillation without changing pads (courtesy APL Healthcare).

3: Plug in the pad leads to the defibrillator.

4: Follow the prompts that the defibrillator gives you (almost all these days are spoken words).

It will tell you to do several things: briefly stop CPR while it "analyses" the electrical signals coming from the heart via the pads.

It will probably tell you to continue CPR, at the rate of 30 compressions to two breaths, until it gives the next instruction.

If it wants to deliver a shock, it will tell you. Fully automatic defibs say something like "stand clear. Delivering shock in 3-2-1 (seconds)". Manual defibs will tell you to "Shock now – press red button".

Even if you don't know how to perform CPR, in some cases the AED will tell you – either by illustrations or by voice commands. Some advanced models will even tell you if your compressions aren't deep enough or too slow.

Make sure that no-one is touching the victim during analysis or shock – the latter for obvious reasons; the former because the minute electrical signals in some else's body may in fact interfere with what the AED is trying to read in the victim.

Then what?

Simply follow the instructions the AED gives you. It may be that it advises that no shock is possible, or that pulse has been restored, or a variety of other scenarios. Hopefully, by this time the ambulance has arrived and they will take over and treatment from you.

Buying an AED

As we said earlier, we hope that this article may encourage businesses and companies to invest in their own AED and train some of their people to use it. Make sure everyone knows where it is!

Or at the prices of these units these days, why not get together with a few neighbours and buy one for home – especially if you have older people either living with you or close by?

Remember, though, that sudden cardiac arrest is no respector of age – whether by accident, trauma, disease or illness, it can strike at any age!

Acknowledgement:

Our thanks to Gary Beauchamp, of First Aid Plus, Sydney (02 9905 0155), for assistance in preparing this feature.

On the left is a "normal" beating heart waveform, showing the rhythmical compression which pumps blood. This is referred to as a "sinus" rhythm. Compare this to the uncontrolled and basically useless waveform of a heart in ventricular fibrillation. If not stopped (and that's the job of a defibrillator) the lack of oxygenated bloodflow will quite quickly start to cause damage to the heart muscles and to the brain (and other organs). Untreated, death is usually the end result.

Which AED is right for YOU?

Choosing an AED is not all that simple: the best advice we can give is to look for one which has a low "consumables" cost as well as an acceptable initial price.

AED Model	Price (Dec15) (if known)	Replacements Pads	Replacements Battery	Available From	Phone	Web
Defibtech Lifeline	$3135 (not known)	(not known) (not known)		First Aid Plus or Defibtech	(02) 9905 0155 1300 853 563	www.firstaidplus.com.au www.defibtech.com.au
HeartOn A10	$1950 $1950	$109.95	$199.00 (not known)	Australian First Aid or APL Healthcare	1300 975 889 1300 727 580	www.australianfirstaid.com.au www.aplhealthcare.com.au
HeartOn A15	$2250 $2250	(not known) (not known)		Australian First Aid or APL Healthcare	1300 975 889 1300 727 580	www.australianfirstaid.com.au www.aplhealthcare.com.au
Heartsine samaritan PAD 500P	(not known) $2850 $2860	(not known) (not known) (not known)		Aero Healthcare or APL Healthcare or Recovery Defibrillators	1800 628 881 1300 727 580 0413 223 472	www.aerohealthcare.com.au www.aplhealthcare.com.au www.recoverydefibrillators.com.au
Heartsine samaritan PAD 360P	(not known)	(not known)		Aero Healthcare	1800 628 881	www.aerohealthcare.com.au
Heartsine samaritan PAD 350P	$2150	(not known)		Recovery Defibrillators	0413 223 472	www.recoverydefibrillators.com.au
Heartsine samaritan PAD 300P	$2400	(not known)		APL Healthcare	1300 727 580	www.aplhealthcare.com.au
Laerdal HeartStart First Aid	$2390 (not known) (not known)	$108	$250 (not known) (not known)	Laerdal or Australian Defibrilators or St John	1800 331 565 1300 333 427 1300 360 455	www.laerdal.com.au www.aeds.com.au www.stjohn.org.au
Laerdal HeartStart Frx	(not known) (not known) $3200	(not known) (not known) $106	 (not known) $250	Laerdal or Australian Defibrilators or St John	1800 331 565 1300 333 427 1300 360 455	www.laerdal.com.au www.aeds.com.au www.stjohn.org.au
LifePak CR Plus	$2595	(not known)		First Aid Plus	(02) 9905 0155	www.firstaidplus.com.au
Mindray Beneheart	(not known)	(not known)		Australian Defibrilators	1300 333 427	www.aeds.com.au
Powerheart G3	(not known) $2950 $2750	(not known) $90	 $210 (not known)	Cardiac Science or Australian Defibrilators or Recovery Defibrillators	(03) 9429 2666 1300 333 427 0413 223 472	www.cardiacscience.com.au www.aeds.com.au www.recoverydefibrillators.com.au
Powerheart G5	(not known) (not known) (not known) $2750	(not known) (not known) (not known) (not known)		Cardiac Science First Aid Plus or Australian Defibrilators or Recovery Defibrillators	(03) 9429 2666 (02) 9905 0155 1300 333 427 0413 223 472	www.cardiacscience.com.au www.firstaidplus.com.au www.aeds.com.au www.recoverydefibrillators.com.au
Schiller Fred Easy	(not known) $1800	(not known) $100		Schiller Australia Pty Ltd or Recovery Defibrillators	(02) 4954 2442 0413 223 472	www.schiller.com.au www.recoverydefibrillators.com.au
Schiller Fred Easyport	(not known) $2900	(not known) $100	 $130	Schiller Australia Pty Ltd or Recovery Defibrillators	(02) 4954 2442 0413 223 472	www.schiller.com.au www.recoverydefibrillators.com.au
Zoll AED Plus	(not known) $2795 (not known) (not known)	(not known) (not known) (not known) (not known)		Zoll Medical Australia or Defib Shop or Australian Defibrilators or St John	1800 605 555 1300 729 575 1300 333 427 1300 360 455	www.zoll.com.au www.defibshop.com.au www.aeds.com.au www.stjohn.org.au

From our research, any of these AEDs appear to be quite suitable for office/factory/building use where untrained users may need to operate them. However, this is not an exhaustive list. These days, most AEDs operate in a similar way but like any electronic device, might go about it their own way! Some, for example, monitor CPR and will tell you if the compression depth is insufficient. Others may record data from the heart which can be used later by a medical professional to review the treatment given and if necessary, tailor ongoing care.

The suppliers listed may or may not have stock and may have price changes, especially if they were on special offer when we checked.

Any prices shown are ex supplier's websites. Many do not list prices of either the AEDs or their consumables (they want you to call them!).

We suggest calling the numbers shown and/or visit their websites to determine features and availability.

SC

The Micromite LCD BackPack

...add a touch-screen LCD to your next project

By Geoff Graham

The Micromite LCD BackPack combines a full colour touch-sensitive LCD panel with a low-cost 32-bit microcontroller running a BASIC interpreter. It packs an incredible amount of power at an amazingly cheap price and will leave you thinking up project after project where you could put it to good use.

AS ANYONE with a smartphone or tablet is keenly aware, a touch-sensitive colour graphics LCD is the primary input and output interface for a whole range of products. These include not only smartphones and tablets but also air-conditioners, vehicle controls and GPS units, plus simpler devices such as coffee makers. Using the LCD screen, the user can clearly see what the product is doing and by using the touch screen, they can set options and control the device's operation.

So wouldn't it be great to have the same capability in your next creation? Well now you can, with the Micromite LCD BackPack. It's based on SILICON CHIP's Micromite Mk2 microcontroller running a BASIC interpreter and a 240 x 320 pixel colour LCD panel with a touch-sensitive interface. The LCD panel can be purchased on eBay for less than $10 and by adding the low-cost Micromite and a few other components, you have a complete controller/display package.

By using the easy-to-learn BASIC programming language, you can create a professional graphical interface for your next creation, be it a reticulation controller, battery monitor, temperature controller or some other project that you probably haven't yet thought of. With just a few lines of BASIC, you can display text and draw graphs and symbols. The touch sensitive input can be queried from within BASIC, so the display is all you need to use and control the gadget. It really is that easy!

It's also easy to build, uses just a few parts and costs less than $25. What are you waiting for? Start creating.

The Micromite

Regular SILICON CHIP readers will remember the Micromite which was introduced in May 2014, followed by an updated version, the Micromite Mk2 in the January 2015 issue. These both use a low-cost 32-bit PIC32 microcontroller running a Microsoft compatible BASIC interpreter called MMBasic.

The BASIC language used by the Micromite is easy to use, yet powerful. It has the ability to detect logic signals (ie, on/off) as well as measure voltages, frequency, temperature, hu-

midity and more. Other functions include an infrared remote control input, support for numeric keypads and an in-built clock.

Programs are stored in the chip's internal flash memory and can be edited on the Micromite using its in-built full screen editor, via a serial interface. A program can be configured to run immediately on power up so that the Micromite acts as a pre-programmed custom chip and the user need not know anything about what is running inside.

A powerful feature of the Micromite is the range of communications protocols that it supports. These include I²C, asynchronous serial, RS-232, IEEE 485, SPI and 1-Wire. These can allow your program to communicate with other chips and sensors and to send data to test equipment. The 28-pin Micromite used in the LCD BackPack has 11 spare input/output pins, so there is plenty of capability for controlling and interacting with the outside world.

Features & Specifications

- Colour TFT LCD with 320 x 240 pixels, 65,536 colours, and 2.2-inch, 2.4-inch or 2.8-inch diagonal measurement.
- Touch sensitive screen with the touch coordinates reported in pixels.
- Microchip 32-bit 48MHz microcontroller with 256KB flash memory and 64KB of RAM.
- 11 input/output pins. All can operate as digital input/outputs and four can operate as analog inputs. Three additional I/O pins for SPI use.
- Digital I/O sink or source capability of 15mA.
- MMBasic interpreter with 59KB program space and 53KB RAM (for variables and other uses). Programs can be 2500 lines or more in size.
- Graphic commands include CLS, PIXEL, LINE, BOX, RBOX, CIRCLE, TEXT and BITMAP, using any of the 65,536 colours.
- Communications protocols include I²C, asynchronous serial, RS232, IEEE 485, SPI and 1-Wire.
- Built in support for IR remote controls, temperature and humidity sensors, distance sensors, numeric keypads and battery-backed clocks.
- Power supply: 4.5V to 5.5V.
- Current drain: 175mA at normal screen brightness; 225mA at full brightness (40MHz CPU speed).
- Dimensions: 50 x 86 x 27mm for 2.8-inch LCD; 45 x 77 x 27mm for 2.4-inch LCD.

ILI9341-based LCD panel

The ILI9341 is a graphics LCD controller that is often referred to as a COG device (Controller On Glass). This means that the controller chip is bonded directly to the glass substrate used for the LCD. LCD panels using this technique are manufactured in very large numbers for use in common consumer products such as microwave ovens and refrigerators. As a result, they are startlingly cheap. You can find them on eBay for under $10 and that often includes free freight.

This is incredible value considering what you get, especially when compared to the old standby for DIY microcontroller projects, the tiny 2-line 16-character LCD module. That's now so "last century"!

The display supported by the Micromite has 270 x 340 pixels, 65,536 colours and comes in three different sizes – 2.2 inch, 2.4 inch and 2.8 inch diagonal. Most versions also have a built-in resistive touch controller, so you can draw buttons and symbols on the screen and users can then select these by simply touching the screen.

MMBasic 5.1

The latest version of MMBasic used by the Micromite Mk2 includes many improvements but the stand-out feature is its support for ILI9341-based LCD panels. There are six basic commands that interact with the display, the simplest being PIXEL which allows you to set a single pixel to any one of 65,536 colours. You can also draw lines with the LINE command, circles with the CIRCLE command and boxes with the BOX command. These commands have many options so, for example, you can control the width and colour of the lines as well as the colour used to fill boxes and circles.

The TEXT command will display text in any position on the display panel in the same 65,536 colours. More than a dozen fonts are available, ranging from tiny to large, and these include graphical icons which can be used to liven up the display.

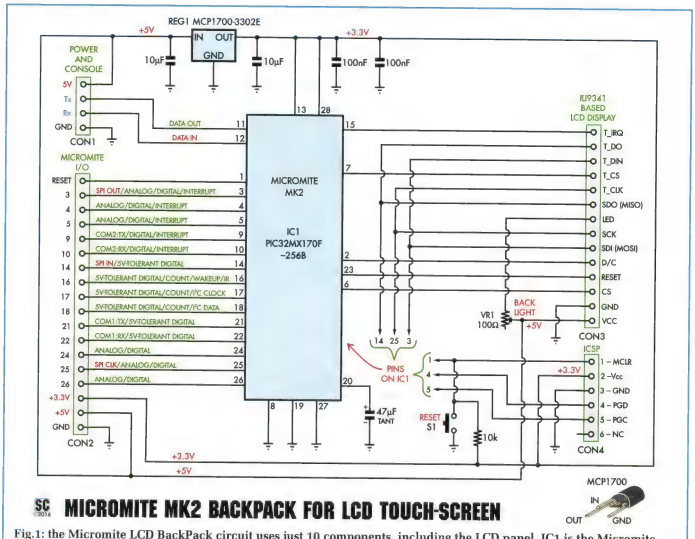
Most cheap LCD panels also have a resistive touch screen and MMBasic 5.1 includes full support for detecting a touch on the screen via the TOUCH() function. This will return the X and Y coordinates (in pixels) of where the screen is touched so that your program can react accordingly.

Using the drawing commands, you can draw a button on the screen and then monitor the touch function to see if that button has been pressed. The touch feature is so convenient that you will be able to dispense with physical switches and/or knobs in many projects.

Micromite LCD BackPack

The Micromite LCD BackPack brings

The Micromite LCD BackPack incorporates graphic drawing capabilities with touch sensitivity, so it's easy to use it as a user input/output interface in a project. In this case, the display shows a keypad which can be used to enter a number.



MICROMITE MK2 BACKPACK FOR LCD TOUCH-SCREEN

Fig.1: the Micromite LCD BackPack circuit uses just 10 components, including the LCD panel. IC1 is the Micromite which does most of the work, while IC2 is a voltage regulator supplying 3.3V to IC1. There is another voltage regulator built into IC1 which supplies 1.8V for the CPU inside this IC. The 47µF capacitor on pin 20 (Vcap) stabilises this regulator and it is critical that a high-quality capacitor, such as a tantalum type, is used in this position.

all three of these elements together. It is a small PCB that is designed to piggy-back on an ILI9341-based LCD panel, making a two-layer "sandwich". It uses just 10 components and will take less than half an hour to build.

The backpack is designed so that it and its LCD panel can be plugged into a solderless breadboard with a 0.1-inch pitch. This allows interface circuitry to be tested and debugged in an easy-to-use environment. Then, once debugged, the circuit can be transferred to a custom PCB or strip board and mounted on the back of the BackPack, making a compact three-layer sandwich.

The accompanying photographs give some examples of what you can use the Micromite LCD BackPack for. We experimented with a battery monitor, digital speedometer and an engine monitor. But as you may have realised by now, the possibilities are endless.

Referring to the circuit in Fig.1, you can see that the Micromite LCD BackPack is about as simple as it gets. The main power input is 5V and this is used to directly power the LCD. It is also fed to a small 3-pin regulator that provides 3.3V for the microcontroller.

The microcontroller used for the Micromite is the Microchip PIC32MX-170F256B. This device has a 32-bit processor running at up to 50MHz, 256KB of rewritable flash memory and 64KB of RAM; not bad for something so cheap.

Most pins on the Micromite run to the four main connectors:

- CON1 is the power input and the console (more on that later);
- CON2 is the main I/O connector and it is here that you interface the Micromite LCD BackPack to the outside world;
- CON3 is the connector dedicated to the ILI934-based LCD panel; and
- CON4 is the ICSP (In-Circuit Serial Programmer) connector which is used to load the MMBasic firmware into a blank microcontroller. We specified a rightangle 6-pin header for this connector, as that allows a programmer such as the PICKit3 to plug into CON4 even when an LCD panel is attached.

The only other components of note are S1 which is a small pushbutton used to reset the processor and R1 which is a 100Ω trimpot that's used to adjust the brightness of the LCD's backlight. R1 is in series with the power to the backlight LEDs, so it limits the current drawn by them and therefore the brightness.

Note that the LCD panel also has a

This view shows the 2.8-inch touch-screen LCD panel. The 2.4-inch panel is slightly smaller but is otherwise virtually identical in appearance. Both display sizes will plug into either BackPack PCB and will work perfectly. The only issue with a mismatched display and BackPack PCB is that a special physical mounting arrangement would be required.

A rear view of the 2.4-inch LCD panel (the 2.8-inch panel looks the same except for its slightly larger dimensions). Note the 16-pin touch controller chip to the bottom right. There are a number of different displays on the market so make sure that the display you purchase matches this photograph to ensure that it is compatible with the Micromite LCD BackPack PCB.

3.9Ω resistor in series with the backlight so you will not burn out the backlight if you wind R1 all the way down to 0Ω.

Sourcing the LCD panel

As stated, the ILI9341-based LCD panels come in three sizes: 2.2-inch (56mm), 2.4-inch (61mm) and 2.8-inch (71mm) diagonal. **Generally, the 2.2-inch display does not have a touch-sensitive screen while the 2.4-inch and 2.8-inch displays do.** The display also includes an SD card socket but that is not supported by the Micromite Mk2 due to memory limitations.

The best place to find a suitable display is on eBay but other online markets such as Alibaba also have them, as well as some online retailers. There are many variations on offer so make sure that the display that you purchase matches the photographs in this article. This is important – the Micromite has been extensively tested with the photographed displays so you can be sure that they will work.

Other features to look out for in a compatible display are a red PCB, a resolution of 240 x 320 pixels and an SPI interface. Often, the description will emphasise that the display is for use with the Arduino but that is not relevant; they work just as well with the Micromite.

On eBay, the best way to find a suitable display is to search for the phrase "ILI9341 LCD". You should find many displays ranging in price from US$6 upwards. **Note that there are some 2.4-inch displays on the market that omit the touch sensitive controller** so if you need that feature, make sure that it is confirmed in the seller's description.

Because the 2.2-inch display does not normally include a touch panel we did not design a PCB for that size but we did design separate PCBs for the 2.4-inch and 2.8-inch displays. The only difference between the two boards is that their dimensions and mounting holes match the corresponding display; otherwise they are identical.

All three display sizes will plug into either-sized PCB and will work perfectly. So your only issue with a mismatched display and PCB is that you will need to use a different physical mounting arrangement.

Construction

Construction is quite simple but before you commence you need to consider a few options. If you are buying a pre-programmed chip for the Micromite you could leave out CON4 – the programming connector. Also you do not necessarily have to use an LCD panel with the Micromite BackPack. It could be just the Micromite that you need and in that case CON3 can be omitted.

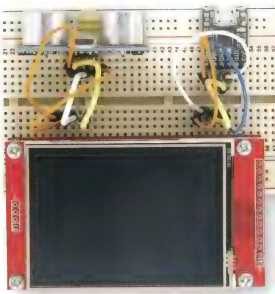
Finally, you may want to run wires directly to CON2. In that case, you can omit the pin header for that connector.

As usual, you should start construction with the low profile components and work your way up to the bigger items such as the connectors. We recommend using a socket for IC1 as that will enable you to swap out the microcontroller if you suspect that you have damaged it.

The 14-pin female connector used for CON3 (to connect the LCD display) can be difficult to source. You can buy them on eBay or you can do what we did and cut down a longer connector to size and then use a file to smooth the rough edge so that it looks presentable.

The reset pushbutton switch (S1) can be mounted on either side of the board. Mounting it on the non-component side may make it easier to reach when you have the board and LCD panel fastened together.

Note that the 10µF and 47µF capacitors are polarised (the longer lead is the positive) so make sure that they are orientated according to the silk



The BackPack PCB is designed so that it can be plugged into a solderless breadboard. This allows any interface circuitry to be tested and debugged before a PCB is designed.

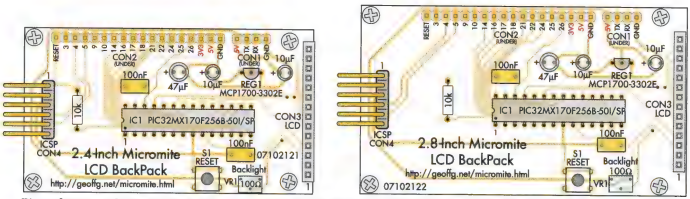


Fig.2: these two diagrams show the parts layout on the BackPack PCB for the 2.4-inch LCD at left and the 2.8-inch LCD at right. Note that pin headers CON1 & CON2 at the top mount on the rear of the PCB (both versions).

screen on the PCB. **The 47µF capacitor is particularly critical and must be a tantalum type, not electrolytic.** A multi-layer ceramic capacitor could also be used in this location but they are generally SMD types for this sort of value. The final PCBs have provision for SMD or through-hole capacitors.

Pin headers CON1 (console + power) and CON2 (I/O pins) should be mounted on the underside (non-component) side of the board, as shown in the photos. Don't mistakenly mount them on the top of the board because they would then be impossible to reach when an LCD panel is attached.

Before you plug the microcontroller into its socket it would be prudent to apply power and check that 3.3V is across the correct socket pins and that +5V is on the correct pin on CON3. With that check made, you can remove the power and plug in IC1 and the LCD panel.

The BackPack PCB and the LCD panel can then be fastened together on all four corners using M3 x 12mm tapped spacers and M3 x 6mm machine screws (or, as shown in the photos, 16mm machine screws with nuts).

Be careful when handling the LCD panel. The ILI9341 controller is sensitive to static electricity and can be easily destroyed with careless handling. Make sure that you are grounded when handling the display and avoid touching the connecting pins.

Finally, if you have a blank PIC32 microcontroller, it should be programmed with the latest Micromite firmware which can be downloaded from the SILICON CHIP website. Refer to the accompanying panel for the details on how to do this.

Connecting the console

In order to write and debug BASIC programs on the Micromite, you use the console. This is a serial interface running at 38,400 baud and which uses TTL signal levels. This is similar to the RS-232 interface on older computers but the TTL signal level is inverted and swings from zero to 3.3V.

There are quite a few USB-to-serial converters on the market (see the panel below). These provide a TTL level serial interface on one side and a USB interface on the other. When connected to a computer running Windows, Mac or Linux, the converter will appear as a virtual serial port. On a Windows computer, it often appears as a high numbered COM port, eg, COM12 or COM45.

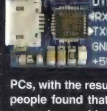
The serial interface side of the converter will generally have a ground pin and a 5V power output pin and these can be connected to the corresponding pins on CON1 on the Micromite BackPack. The serial converter will then provide power to the backpack and the attached LCD, which is handy when you are editing or testing a program. If you do not need the converter (perhaps you have a working program), you should use the GND and 5V pins on CON1 as the main power input.

The USB-to-serial converter will also have two pins marked TX (or similar) for transmit and RX (or simi-

USB-to-Serial Converters

There are many USB-to-serial converters on the market, ranging in price from $2-20. One of the most popular types is based on the FTDI FT232RL chip. In fact, this chip has become so popular that some companies make clones of it, even down to the markings which imitate the genuine chip.

This understandably upset FTDI and they released a new Windows device driver that not only refused to work with a clone chip but also disabled the chip so that it would not work with any other computer or driver. This driver was also included in an automatic update that Microsoft provided for Windows-based



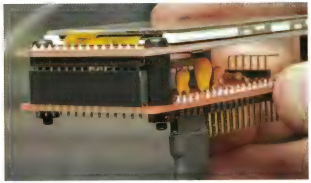
USB-to-serial converters based on the CP2102 chip can be found on eBay for just a few dollars.

PCs, with the result that thousands of people found that their USB-to-serial converters suddenly stopped working and were worthless.

The problem with this is that, at the time of purchase, there is no way of knowing if a new FT232RL-based converter uses the genuine chip or not. You will only find out when you receive the converter and try plugging it into a Windows computer.

An alternative that does not carry this risk are converters based on the Silicon Labs CP2102 chip, as shown in the accompanying photograph. They can be found on eBay for a few dollars (search for "CP2102"). We have tested them on the Micromite with both Windows 7 and Windows 10 and can report that they work just fine.

Because USB-to-serial converters based on the CP2102 are so cheap (often less than the retail price of the USB cable), you can afford to permanently connect one to the Micromite BackPack. This is handy if ever you need to come back and modify the program later.



The photo at left shows the fully-assembled PCB for a 2.4-inch LCD panel (the 2.8-inch version is nearly identical). The connector to the left is for the in-circuit programmer, the connector on the right is for the LCD panel and the two on the top are for input/output and the console. The view above right shows how the LCD panel plugs into the BackPack PCB, with the two then secured together using M3 x 12mm untapped spacers and machine screws (see text).

The USB-to-serial converter should be connected via colour-coded flying leads to a 4-way header socket, so that it can be plugged into CON1 on the underside of the BackPack PCB (see photo above right). Use a red wire for +5V, white for TX, yellow for RX and black for GND.

lar) for receive. **The TX pin of the serial converter must go to the RX pin of the Micromite and the RX pin must go to the TX pin.** This may sound confusing but it makes sense when you think about it.

Basically, the transmit signal from the converter (the TX pin) needs to go to the receive pin (RX) on the Micromite so that the Micromite can receive data sent by the converter. Similarly, transmit from the Micromite must go to receive on the converter.

When you plug the USB side of the converter into your computer you may have to load a driver to make it work with the operating system. Once this is done you should note the port number created for the virtual serial connection. In Windows, this can be done by firing up Device Manager and checking the "Ports (COM & LPT)" entry for a new COM port.

Terminal emulator

With this information, you can start up a terminal emulator program on your desktop computer. This program acts like an old-fashioned computer terminal where it will display text received from a remote computer and any key presses will be sent to the remote computer over the serial link.

For Windows, we recommend Tera Term version 4.88 which has a host of features and is free. It can be downloaded from http://tera-term.en.lo4d.com/

Once you have your terminal emulator running, you should configure it for the serial port number that you recorded previously and set the interface to 38,400 baud, 8 bits data, no parity and one stop bit. This is the standard used by the Micromite.

Then you can hit the Enter key on the terminal emulator and you should see the Micromite command prompt (a ">" character). If you press the reset button on the BackPack, you should see the full copyright banner as shown in Fig.5.

If you do not want to use a desktop computer you can use the ASCII Video Terminal featured in Silicon Chip, July 2014. This will convert a PS/2 keyboard and a VGA monitor or old TV set into a full terminal emulator

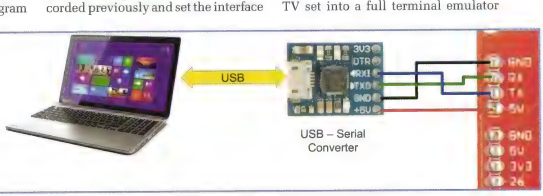


Fig.3: the Micromite LCD BackPack is connected to your PC using a USB-to-Serial converter. All programming and control of the Micromite is carried out via the console using a terminal emulator on the PC. Once the program is debugged and running, you can then disconnect the USB-to-Serial converter.

Programming The Micromite Firmware

Before you can use the Micromite, you must program it with the Micromite firmware. This can be downloaded from the SILICON CHIP website and includes the MMBasic interpreter which is what you need to start programming in BASIC.

The easiest option though is to purchase the chip already programmed from the SILICON CHIP Online Shop. This can either be obtained separately or as part of a kit (see parts list for further details). Alternatively, you can build the low-cost PIC32 programmer described in the November 2015 issue and program the chip yourself using the downloaded firmware.

Yet another option is to use Microchip's PICkit 3 programmer. This costs around $60 plus freight. The Micromite LCD BackPack is designed to accept the PICkit 3, even when the LCD display is attached. The accompanying photo shows just such a set-up

To use the PICkit 3, you first need to download and install Microchip's MPLAB X software development system on your personal computer. This comes in various versions for Windows, Mac OS and Linux. Unfortunately, the full install includes a lot of stuff that you don't need (such as a full integrated development environment) but the important part is MPLAB IPE which is the programming component (IPE stands for Integrated Programming Environment). This is normally installed as an icon on your PC's desktop.

Using MPLAB IPE is reasonably intuitive. You simply select the PICkit 3 as the programmer, select the type of chip that you are programming (PIC-

which will work perfectly with the Micromite.

MMEDIT

Another convenient method of creating and testing your programs is to use MMEDIT. This program was written by SILICON CHIP reader Jim Hiley, from Tasmania. It can be installed on a Windows or Linux computer and allows you to edit your program on your PC and then, with a single button click, transfer it to the Micromite for testing.

MMEDIT is easy to use, with colour-coded text, mouse-based cut and paste and many more useful features such as bookmarks and automatic indenting. Because the program runs on your PC, you can save and load your programs to and from the computer's hard disk.

It's free and can be downladed from: http://www.c-com.com.au/MMedit.htm

Driving the Micromite

The Micromite User Manual (available for download from the SILICON CHIP website) runs to just over 90 pages and we cannot cover that much detail here. So, the following is intended more to give you the "flavour" of how to program the Micromite using MMBasic.

When you first connect to the Micromite with a terminal emulator you will see the command prompt, the "greater than" symbol (>). At this prompt, you can enter almost any command in the language to test features, configure options or run a program.

For example, if you typed **PRINT 2 + 2** and then hit the enter key, MMBasic would respond with 4 and then display the prompt again. This is immediate mode and is useful for testing commands and their effects.

Most times, you will want to run a program that consists of more than one line and in this case there are three ways of getting your program into the Micromite. The first is by using the EDIT command which will start the Micromite's built-in editor. Using the editor, you can seamlessly enter and edit programs up to the maximum size that the Micromite can handle (about 59KB).

Another way to load a program is via the AUTOSAVE command. This instructs the Micromite to take anything that is sent to it over the console line and save it to program memory. The AUTOSAVE command will terminate when a Ctrl-z character is received. All terminal emulators have the ability to send a file over the serial line and when the whole file has been sent you can enter Ctrl-z on the keyboard to signal the end of the file.

The third method is to use the XMODEM command on the Micromite. This will cause the Micromite to wait for an XModem transfer from the PC and then receive the program using that protocol. Many terminal emulators, including Tera Term, support the XModem protocol.

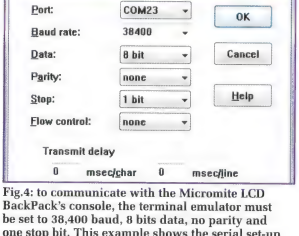


Fig.4: to communicate with the Micromite LCD BackPack's console, the terminal emulator must be set to 38,400 baud, 8 bits data, no parity and one stop bit. This example shows the serial set-up dialog box for Tera Term.

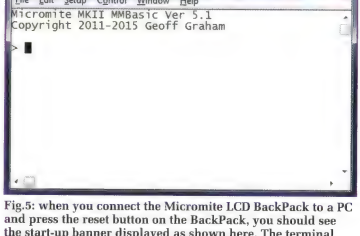


Fig.5: when you connect the Micromite LCD BackPack to a PC and press the reset button on the BackPack, you should see the start-up banner displayed as shown here. The terminal emulator used here is Tera Term.

32MX170F256B), load the firmware (the HEX file) and click on the "Program" button. The PICkit 3 will then program and verify the chip in less than a minute (see the article on using the PICkit 3 in the July 2010 issue for further details).

MMEDIT (the free editing program mentioned earlier) automates this aspect for you. It uses a combination of AUTOSAVE and XMODEM to transfer the program at the click of a button.

Inside the Micromite, the program is saved to non-volatile flash memory. This means that you can turn the power off and the program will still be there when you reapply power. With the program in memory, you can enter the RUN command which will cause the Micromite to start running it.

If an error occurs, the Micromite will print an error message on the console and return to the command prompt. This is where the in-built editor is particularly useful. You can enter the command EDIT and the editor will place the cursor on the line that caused the error. When you have fixed the fault, you press F2 which will instruct the editor to save the program and run it again.

This edit/run cycle is very fast and helps make programming the Micromite a breeze.

Configuring the LCD panel

The first thing that you need to do when you have the Micromite LCD BackPack running and connected to the console is configure it for the LCD. To do this, type the following line at the command prompt and hit the Enter key:

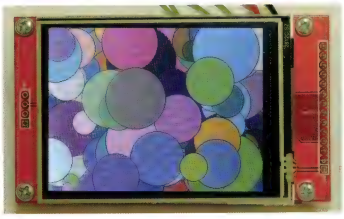
```
OPTION LCDPANEL ILI9341, L, 2, 23, 6
```

This tells the Micromite that the LCD panel is connected and what I/O pins are used for critical signals such as reset and device select. This option only needs to be entered once because the Micromite will store the setting in its internal non-volatile memory and will automatically reapply it whenever power is applied.

Following this command, the Micromite will initialise the display (which should go dark) and return to the command prompt. You can test the display by entering the following at the command prompt:

```
GUI TEST LCDPANEL
```

This will cause the Micromite to draw a series of rapidly overlapping coloured circles on the display. This animated test will continue until you



This photo shows the display when the command GUI TEST LCDPANEL is used. It is animated, with random circles being rapidly drawn on top of each other and makes a good test of the Micromite and LCD combination.

Parts List

1 PCB, code 07102121, 77 x 45mm for 2.4-inch LCD; or code 07102122, 86 x 50mm for 2.8-inch LCD
1 ILI9341-based LCD, 320 x 240 pixels, 2.2-inch, 2.4-inch or 2.8-inch diagonal
1 4-pin tactile switch, through-hole
1 100Ω vertical mounting side-adjust trimpot (Altronics R2579, element14 9608044 or similar)
1 28-pin DIL low-profile IC socket
1 4-pin 0.1-inch male header (CON1)
1 18-pin 0.1-inch male header (CON2)
1 14-pin 0.1-inch female header socket (CON3)
1 6-pin 0.1-inch right-angle male header (CON4)
4 M3 x 12mm tapped spacers
8 M3 x 6mm machine screws OR
4 M3 x 16mm machine screws and matching nuts

Semiconductors

1 PIC32MX170F256B-50I/SP microcontroller programmed with Micromite Mk2 firmware (IC1) (note: a PIC32MX170F256B-I/SP can also be used but will be limited to 40MHz)
1 Microchip MCP1700-3302E/TO voltage regulator (IC2)

Capacitors

1 47µF 16V tantalum or SMD ceramic (3216/1206)
2 10µF 16V tantalum or SMD ceramic (3216/1206)
2 100nF monolithic ceramic

Resistors (1%, 0.25W)

1 10kΩ

Where to buy parts

A complete kit for the Micromite LCD BackPack will be available from the Silicon Chip Online Shop. This includes a 2.8-inch TFT touchscreen and matching PCB, plus the programmed microcontroller and all other parts as listed above.

The PCBs, the pre-programmed PIC32MX170F256B-50I/SP microcontroller & the MCP1700-3302E/TO voltage regulator can also be purchased separately from the Online Shop.

```
CLS
BOX 0, 0, MM.HRes-1, MM.VRes/2, 3, RGB(RED), RGB(BLUE)

DO
  TEXT MM.HRes/2, MM.VRes/4, TIME$, CM, 1, 4, RGB(CYAN), RGB(BLUE)
  TEXT MM.HRes/2, MM.VRes*3/4, DATE$, CM, 1, 3, RGB(GREEN)
  IF TOUCH(X) <> -1 THEN END
LOOP
```

Fig.6: this simple program will display a clock/calendar on the LCD panel.

This is the result of running the test program for a simple clock as described in the text. Note that the font used in the photo is different from the font that you will see.

press any key on the console's keyboard and MMBasic will then return to the command prompt.

To configure the touch feature you should enter the following at the command prompt:

```
OPTION TOUCH 7, 15
```

This command allocates the I/O pins for the touch controller and initialises it. This option is also stored in non-volatile memory and automatically applied on power-up.

You do not have to run this command if your panel does not have a touch-sensitive screen but you must use it if your LCD does have a touch facility – even if you will not be using touch in your program. This is because the touch chip select line could "float", causing the touch controller to respond to commands intended for the panel's ILI9341 controller

With the touch feature configured, MMBasic will know to keep the touch chip select line inactive. Before you can use the touch facility you need to calibrate it. This is done with the following command:

```
GUI CALIBRATE
```

This will cause MMBasic to draw a target at the top lefthand corner of the screen as shown in the accompanying photograph. Next, using a pointy but blunt object, press on the exact centre of the target. After a second, the target will disappear and when you lift your touch another target will appear on the top right.

By repeating the above procedure, the target will be displayed, in turn, on all four corners of the display and the touch feature will be calibrated. When completed, the message "Done. No errors" should be displayed on the console. You also might get a message indicating that the calibration was inaccurate and in that case you should repeat it, taking more care to apply a steady press on the centre of the target.

As before, these calibration details are saved in non-volatile memory and will be reapplied at power up. You can now test the touch facility with the command:

```
GUI TEST TOUCH
```

This will clear the screen and when you touch it, pixels will be illuminated at the touch point. This enables you to test the accuracy of the calibration. Using a stylus, touch the screen and the pixels under the touch point should light. Pressing any key will terminate the test. You can also use this test feature as a simple drawing screen, rather like a high-tech version of the Etch A Sketch.

Fault-finding

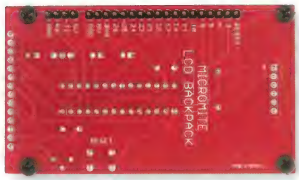
Because it's so simple, there's not a lot that can go wrong with the Micromite LCD BackPack. If the display doesn't light or perform as it should, the first thing to do is check that the correct supply voltages are on IC1's socket and on CON3 (the LCD connector).

That done, check the 5V supply current for the full module, including the LCD. It should range from 100-200mA, depending on the setting of the backlight trimpot. If it is substantially lower than this, check that the PIC32 and the LCD are correctly seated in their sockets.

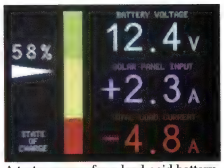
With the LCD removed, the power consumption should be about 25mA. If it is a lot less than this, it indicates that the PIC32 processor has not started up and in that case the 47µF capacitor is the most likely culprit. As previously stated, it must be a tantalum or multilayer ceramic type, not an electrolytic.

This is an example of the display when calibrating the touch screen using the command GUI CALIBRATE.

This is an example of the display when the command GUI TEST TOUCH is used. It illuminates pixels where touched and is a good test for the touch calibration.



The rear side of the Micromite BackPack PCB is silk-screened with the functions and pin numbers of the console and I/O connectors. This makes it easy to identify the correct connector pin when the Micromite BackPack PCB and the LCD panel are fastened together.



A test program for a lead-acid battery state of charge monitor using the Micromite LCD BackPack. The bar on the left shows the state of charge while the numbers on the right display the battery voltage, charging current in amps (from a solar panel) and the discharge current.

If the voltages and power consumption are correct, the problem could be with the console connection. Disconnect the USB-to-serial converter and join its TX and RX pins. Then try typing something into the terminal emulator. You should see your characters echoed back and if that doesn't happen, it indicates a fault with the converter or the terminal emulator.

If the USB-serial converter checks out, the fault could be related to the console connection to the Micromite LCD BackPack. Make sure that TX connects to RX and vice versa and that the baud rate is 38,400. If you have an oscilloscope, you should be able to see a burst of activity on the BackPack's TX line on power up. This is the Micromite sending its start-up banner.

Test program

With the Micromite LCD BackPack working, you are ready to enter a test program. Using any of the three methods mentioned before (EDIT, AUTOSAVE or XMODEM), enter the sample program shown in Fig.6.

This program will display a simple clock/calendar on the LCD panel as shown in an accompanying photo (note that the font used in the photo is different from the font that you will see). Touching the screen will terminate the program.

The program starts by drawing a box with red walls and a blue interior. It then enters a continuous loop where it performs three functions:

(1) It displays the current time inside the previously drawn box. The string is drawn centred both horizontally and vertically in the middle of the box;

(2) It draws the date centred in the lower half of the screen; and

(3) It checks for a touch on the screen. This is indicated when the TOUCH(X) function returns something other than -1. In that case, the program will terminate.

Interfacing

The Micromite LCD Backpack interfaces to the "outside world" via CON2, the main I/O connector. This is designed so that you can plug it into a solderless breadboard or connect to a third board mounted on the back on the BackPack.

The silk-screen on the PCB identifies each pin on the connector. The GND, 5V and 3.3V pins can be used to power your external interface circuitry. The maximum current that can be drawn from the 3.3V pin is 150mA, while the maximum 5V load will depend on your 5V supply. The RESET pin is normally pulled up by the onboard 10kΩ resistor to +3.3V and if you pull it low, the Micromite will reset.

The other I/O pins connect directly to the Micromite and are marked with the Micromite's pin number. Refer to the Micromite User Manual (downloadable from the SILICON CHIP website or from the author's website) for details of what you can do with each pin.

As an example, you could configure one of the analog-capable pins (say pin 4) to measure voltage. The command to do this is:

```
SETPIN 4, AIN
```

Measuring the voltage on that pin is then as simple as using the PIN() function. For example:

```
PRINT PIN(4)
```

This will display the voltage at pin 4 on the console.

Three of the pins on CON2 (pins 3, 14 & 25) are also connected to the colour LCD for communicating with the display using the SPI protocol. For this reason, they cannot be used as general-purpose I/O pins. However, they can still be used for SPI communications if needed; this is why they are included on this connector.

The user manual (http://geoffg.net/micromite.html) describes how to use the SPI interface simultaneously with the LCD and it's not hard to do. However, for normal operation, you should just make sure that you do not use pins 3, 14 & 25 for general I/O.

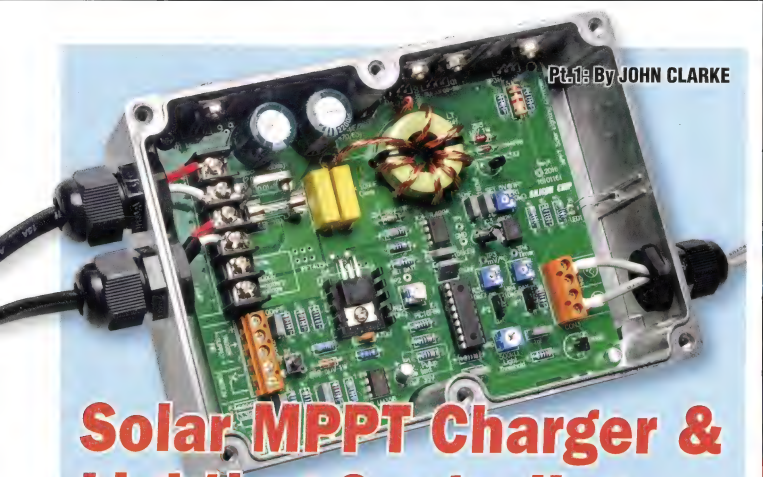
Well, that's it – an inexpensive processor and display package with a host of possibilities. What plans do you have for it? SC

A test program for an engine monitor using the Micromite LCD BackPack. The display updates smoothly, with the needles reacting very quickly to any change. Program courtesy Peter Mather on the Back Shed Forum.

Firmware Updates

For firmware updates & manual please check the author's website at geoffg.net/micromite.html

You should also check out the Back Shed forum (www.thebackshed.com/forum/Microcontrollers) where there are many Maximite and Micromite enthusiasts who are happy to help beginners.



Pt.1: By JOHN CLARKE

Solar MPPT Charger & Lighting Controller

This MPPT charger/light controller will work with 12V or 24V solar panels to charge a 12V or 24V lead-acid or lithium iron phosphate battery. You can then use the battery to run 12V DC lighting or a 12V/24V 230VAC inverter to run lighting or to drive other loads.

SOLAR PANELS are becoming cheaper all the time, so now you can build a low-cost system to power lighting and other loads around your home, your boat or caravan or for a home that's not connected to the grid.

This unit gives you the choice of running a 12V solar panel up to 120W or a 24V panel up to 220W. It can switch lights on at dusk and off at dawn. By including a PIR (passive infrared) detector, you can also have lights switch on with movement detection and off with the timer. You can also manually switch the lights on or off at any time.

The unit incorporates Maximum Power Point Tracking (MPPT) to maximise the output from the solar panel, regardless of the solar intensity, and it provides 3-stage charging for SLA (sealed lead-acid) batteries or 2-stage charging for $LiFePO_4$ batteries. Cell equalisers will be required if using a $LiFePO_4$ battery; more about this later.

Whether you intend operating with a 12V or 24V system, you are not limited to 12V DC lighting. The battery can be used with a 12V or 24V/230VAC inverter of up 600W or more (depending on the size of your battery) to run 230VAC LED downlights, laptop computers, TV sets, power tools and so on. Mind you, while the unit can work with a solar panel rated up to 120W at 12V or 220W up 24V, you can use a smaller panel if that is all you require.

A big advantage of using a 230VAC inverter is that you will have a much larger choice of lights than if you are confined to a 12V DC system.

Fig.1 shows the arrangement of our Solar Lighting Controller and depicts the solar panel, battery and the 12V lighting or 230VAC inverter. Additional inputs to the controller include a light sensor to monitor the ambient light, a PIR detector and a timer.

For use in garden lighting, the light sensor allows the lights to switch on at dusk and they can remain lit for a preset period of up to eight hours, as set by the timer. Alternatively, you may wish to have the lights lit for the entire night and to switch off automatically at sunrise, provided there is sufficient battery charge (and capacity).

For security or pathway lighting, the

lights can be set to switch on after dusk but only when someone approaches the area. In this case, a PIR movement detector switches on the lights, while the timer switches off the lights after a predetermined period, typically about one to two minutes. Periods extending up to the full 8-hour timer limit are available if you need more time.

The actual total wattage of the lights that you can use depends on the application. With its internal Mosfet switching, it will supply a load drawing up to 10A from a 12V or 24V battery. You will get the best efficiency using LED lighting or 12V fluorescent lamps rather than using standard or halogen filament lamps.

Alternatively, the controller can switch a heavy-duty relay to drive a 12V or 24V inverter, as noted above, and it will protect the battery by switching off to prevent over-discharge, since it includes low battery detection, with a cut-off below 11V. This is most important for lead-acid or lithium iron phosphate batteries.

Standby current drain of the Solar Lighting Controller is quite low at 2.2mA but this increases to around 12mA if a PIR detector is used.

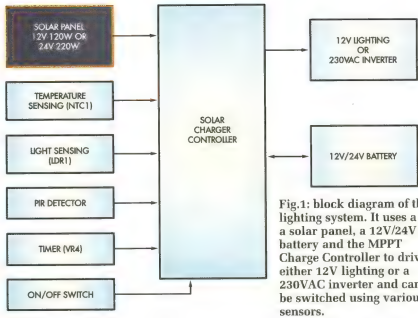


Fig.1: block diagram of the lighting system. It uses a a solar panel, a 12V/24V battery and the MPPT Charge Controller to drive either 12V lighting or a 230VAC inverter and can be switched using various sensors.

Multi-stage charging

As mentioned above, the Controller provides 3-stage charging for lead-acid batteries or a 2-stage charge for LiFePO$_4$ batteries. Fig.2 shows the 3-stage charging with bulk, absorption and float modes. Bulk charge is applied when the battery voltage drops below 12.7V and feeds maximum power from the solar panel until the battery voltage reaches cut-off at 14.4V @ 20°C. Next is the absorption phase where the battery is maintained at the cut-off voltage of 14.4V for one hour, to ensure full charge. After that, the battery is maintained on float charge at 13.5V.

The cut-off voltage for bulk charge and the float voltage is reduced for temperatures above 20°C, in accordance with the battery manufacturers' charging specifications. Typically, this is 19mV per °C for a 12V battery. So at 30°C, the voltages are reduced by 190mV, ie, 14.2V and 13.3V respectively.

The ambient temperature is measured using an NTC (negative temperature coefficient) thermistor which should be located close that the battery or preferably, attached to the case of the battery for more accurate temperature sensing. Charging will not occur if the thermistor is shorted or not connected.

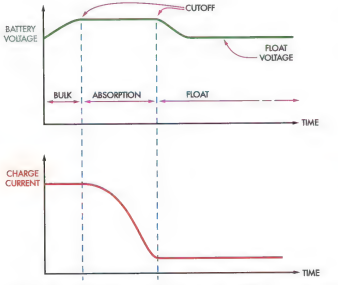


Fig.2: 3-stage charging is used for lead-acid batteries, starting with an initial bulk charge. When the battery reaches the cut-off voltage, the absorption stage takes over to fully charge it. The float stage then maintains the charge.

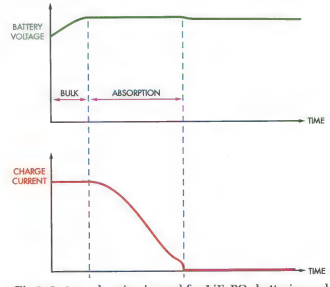


Fig.3: 2-stage charging is used for LiFePO$_4$ batteries and consists of bulk and absorption stages. These stages are exactly the same as for lead-acid batteries but there is no subsequent float charge mode.

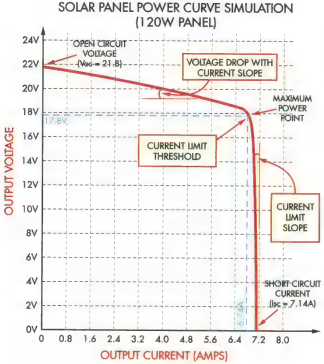


Fig.4: the current/voltage curve for a typical 120W solar panel.

The 2-stage charging used for LiFePO$_4$ batteries is shown in Fig.3 and consists of bulk and absorption stages. In fact, the bulk and absorption stages are exactly the same as for lead-acid batteries but there is no subsequent float charge mode. We based these modes on information to be found at www.powerstream.com/LLLFhtm and similar websites.

Note that it is important that a cell balancer is used when charging LiFePO$_4$ batteries. We intend publishing a suitable cell balancer in our March 2016 issue.

Charge indication

A LED indicator shows the charging stage. It is on continuously for the bulk charge mode; flashes on for 0.5s and off for 0.5s for the absorption mode, and flashes on for one second and off for one second during float mode. If you have a battery that has been discharged below 10.5V, it will be charged with short bursts of current until it reaches 10.5V whereupon bulk charging will begin. This initial charging will be indicated by a short flash of the charge LED every four seconds.

MPPT operation

Fig.4 shows the output of a typical 12V solar panel. It will deliver maximum current when the output is shorted and maximum voltage when the output is open-circuit (ie, no load). So the maximum short circuit current might be around 7.2A and the maximum voltage can be anywhere between 21.8V and 22.5V, or maybe a little more. However, the maximum power output for a nominal 12V 120W panel will be between those extremes, at a load current of 6.74A and a voltage of 17.8V (or very close to those figures).

When we consider the power delivered to the battery, the story becomes more interesting. If we were to connect the 120W solar panel directly to the battery, the charge current would be about 6.9A at 12V (ie, 82.8W) and about 6.8A at 14.4V (ie, 97.9W). Both these values are far less than the 120W available from the solar panel when its voltage is at 17.8V.

Ideally, the solar panel should be operated at peak efficiency, to deliver maximum power. And that is where the Maximum Power Point Tracking (MPPT) aspect of the controller comes into play. It's essentially a switchmode step-down power converter, which increases the available power from the solar panel to the battery with minimal power loss. At the same time, it provides the required 2-stage or 3-stage charging to the battery.

Fig.5 shows how this takes place. When Mosfet Q1 is closed, current from the solar panel flows through paralleled dual diode D1 and this is filtered with two 2200µF capacitors. The current (i1) flows through inductor L1 into the battery. The inductor charges (ie, current rises to its maximum value) and after a short period, Q1 is switched off and the stored charge in L1 maintains current flow (i2) via paralleled dual diode D2. The ratio of the on to off period (duty cycle) for Q1 is controlled so that the solar panel delivers the maximum available power.

The solar panel is not required to supply the peak current into the inductor as this is drawn from the 2200µF capacitors. Incidentally, these capacitors are low ESR (effective series resistance) types, suited to the switching frequency of 31.24kHz.

The voltage from the solar panel is monitored by op amp IC2a while the current is monitored by measuring the voltage across a 0.01Ω shunt resistor. This voltage is multiplied by -45 in op amp IC2b which also acts as a low pass filter. Both op amps feed their signals to microcontroller IC1 and this controls the whole circuit operation.

Circuit details

The full circuit for the Solar Lighting Controller is shown in Fig.6 and is based around a PIC16F88 microcontroller, IC1. This monitors the solar panel voltage and current signals from IC2, a PIR sensor (if used), switch S1, a light dependent resistor (LDR) and an NTC thermistor and controls the lighting using Mosfet Q4.

A 12V supply is provided for the PIR sensor at CON2 via resistor R2 from the 12V battery supply. Many PIR sensors can be operated from a 9-16V supply and in these cases R2 can be a wire link and zener diode ZD4 omitted. If the PIR sensor requires a fixed 12V supply, then R2 should be 270Ω and zener diode ZD4 is included. For 24V operation, R2 should be 1.2kΩ.

A pushbutton switch (S1) is monitored by IC1's RB1 input, normally held high at 5V with a 100kΩ pull-up resistor. Pressing the switch pulls the RB1 input low. S1 is included for test purposes but an external on/off (pushbutton) switch can be connected as well, using two of CON2's terminals. The 100nF capacitor at RB1 prevents interference from causing false switching when long leads are used to an external switch.

Ambient light is monitored using a light dependent resistor (LDR) at the AN5 analog input of IC1. The LDR

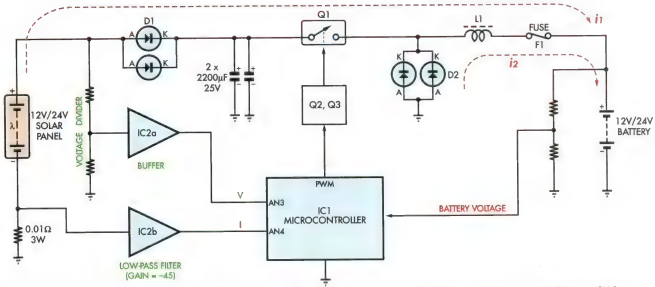


Fig.5: block diagram of the switchmode step-down MPPT Charge Controller. The ratio of the on-to-off period (duty cycle) for Mosfet Q1 (shown here as a switch) is controlled by IC1 which acts in response to the solar panel's current and output voltage. This ensures that the solar panel delivers the maximum available power to the 12V or 24V battery.

forms a voltage divider with a series-connected 100kΩ resistor and trimpot VR5, all across the 5V supply.

In normal daylight, the LDR is a low resistance (about 10kΩ) but this rises to over 1MΩ in darkness. Therefore, the voltage at the AN5 input will be inversely proportional to the ambient light. If the voltage across LDR1 is below 2.5V, IC1 determines it is daylight; above 2.5V it reads it as dark.

This measurement is made when Mosfet Q5 is switched on, tying the lower end of the LDR close to 0V. VR5 allows threshold adjustment of the LDR sensitivity.

Link Options

There are three options available for turning on the lighting: (1) only at night; (2) only in daylight; and (3) both day and night. The position of link JP1 selects the first two options, while the third option operates with the link in the night position but with the LDR left out of circuit. The lamp can also be switched on using pushbutton switch S1 (internal or external), provided the ambient light level is correct according to the selection made with JP1.

When JP2 is in the PIR position, the lamp can also be switched on when the PIR detects movement; again dependent on ambient light, according to the JP1 selection. If JP2 is set to the LDR position, the PIR does not switch on the lamp and the lamp is switched on at the change of ambient light, day to

Features & Specifications

Main Features

- 12V or 24V operation
- 120W/220W solar panel rating
- 120W/600W lighting
- Lamps on with movement, on/off switch or with ambient light changes
- 3-stage charging for SLA batteries
- 2-stage charging for LiFEPO$_4$ batteries
- Switchmode charger operation with maximum power ponting tracking (MPPT)

Specifications

- Lamp driver: up to 10A
- Lamp Timer: 2s to 8 hours
- Lamp switch on: PIR sensor or LDR light level sensor
- Low battery cut-off voltage: 11V
- Quiescent current: 2.2mA
- Charge compensation: adjustable from 0 to 50mV per °C, reducing charge voltage above 20°C and increasing below 20°C. No increase below 0°C. (SLA only) (For LiFePO$_4$ set at 0mV per °C)
- Open or short circuit thermistor LED warning
- Low battery charge LED indication: at less than 10.5V charging via a 6.25% duty cycle charge burst (Charge indicator flashes 260ms each 4.2s)
- Bulk charge initiation when battery drops below 12.7V
- Charge LED indicator: bulk charge = continuously lit; absorption = flashing 0.5s on, 0.5s off; float = 1s on, 1s off
- Charger: charging starts when solar panel output is >12V

Table 1: Lamp Operation Options

JP1	JP2	Lamp On	Lamp Off
Day position	LDR position	Night to day transition. With S1 during day	Day to night transition, with S1 or timer time-out
Night position	LDR position	Day to night transition. With S1 during night	Night to day transition, with S1 or timer time-out
Night position	LDR position and with the LDR disconnected from CON3	S1 during day or night	Timer time-out or S1
Day position	PIR position	PIR movement detection or with S1 during the day only	Day to night transition, with S1 or timer time-out
Night position	PIR position	PIR movement detection or with S1 during the night only	Night to day transition, with S1 or timer time-out
Night position	PIR position and with the LDR disconnected from CON3	PIR movement detection or with S1 during the day or night	Timer time-out or with S1

night or night to day (again, dependent upon JP1) – see Table 1.

Timer

The lamp can also be switched off using either a timer or the ambient light level. The various options are summarised in Table 1. The lamp ON period is adjustable using trimpot VR4, connected between +5V and the drain of Q5.

When Q5 is switched on, the trimpot is effectively connected across the 5V supply. The wiper voltage is monitored at the AN0 input of IC1. We'll cover the procedure for adjusting VR4 later.

Lamp driver

The lamp or lamps are powered on using Mosfet Q4. This is switched on with gate voltage from the RB0 output of IC1. Q4 is an IRF1405 and this can be driven using a low-voltage gate signal such as the 5V from IC1. The expected voltage drop between drain and source is around 0.12V when conducting 10A. A small heatsink ensures that this Mosfet runs relatively cool.

Note that if an inverter is to be controlled, Q4 is used to switch a heavy-duty relay.

Charging

For charging, we use the switchmode step-down circuit previously described in Fig.5. Mosfet Q1 is a P-channel type that switches on with a gate voltage that is negative with respect to its source. The voltage at Q1's source (from the solar panel and diode D1) can range up to about 22V when the solar panel is not delivering current.

D1 is a twin-diode package which has the advantage that both diodes are closely matched for forward voltage, since they are both on the same silicon die. This means that they will share current equally when they are connected in parallel, to give a total rating of 20A.

Mosfet Q1 is controlled by NPN transistor Q3 that's driven by the PWM output at pin 9 of IC1 via a 100Ω resistor. Q3's emitter is connected to ground via another 100Ω resistor. With about 5V at Q3's base, the emitter is at about 4.3V and so there is 43mA through its collector. When Q3 is on, Mosfet Q1's gate is pulled negative with respect to its source via diode D3 and the 10Ω resistor, thus switching Q1 on. Q1's gate is protected from voltages in excess of 18V (which could damage it) by zener diode ZD3. Q3's emitter resistor is set at 100Ω so that ZD3's current is limited to 43mA.

While ever Q3 is on, NPN transistor Q2 is off since the base is one diode drop below the emitter, due to D3 being forward biased. Conversely, when IC1 switches Q3 off, Q2's base is pulled to Q1's source voltage via a 1kΩ resistor. This switches Q2 on, pulling Q1's gate to its source and thus switching it off. Q1 is switched on and off by IC1 at 31.24kHz.

Voltage/temperature monitoring

The battery voltage is monitored at IC1's AN2 input via optocoupler OPTO1 and a resistive divider comprising a 22kΩ resistor and 20kΩ trimpot VR2. This divider is adjusted using VR2 so that the voltage appearing at AN2 is actually 0.3125 times the battery voltage.

The reason for this is so that the 5V limit of analog input AN2 is not exceeded. For example, a 15V battery voltage will be converted to just 4.69V. We'll cover this in the setting-up procedure later.

The resistive divider is not directly connected to the battery but via the transistor within optocoupler OPTO1 and this connects the battery voltage to the divider whenever the LED within OPTO1 is on. The collector-emitter voltage of the transistor has a minimal effect on the battery voltage measurement, as it is only around 200μV. The divided voltage is converted to a digital value by IC1. The optocoupler's LED is driven from the 5V supply through a 470Ω resistor to 0V when Mosfet Q5 is switched on.

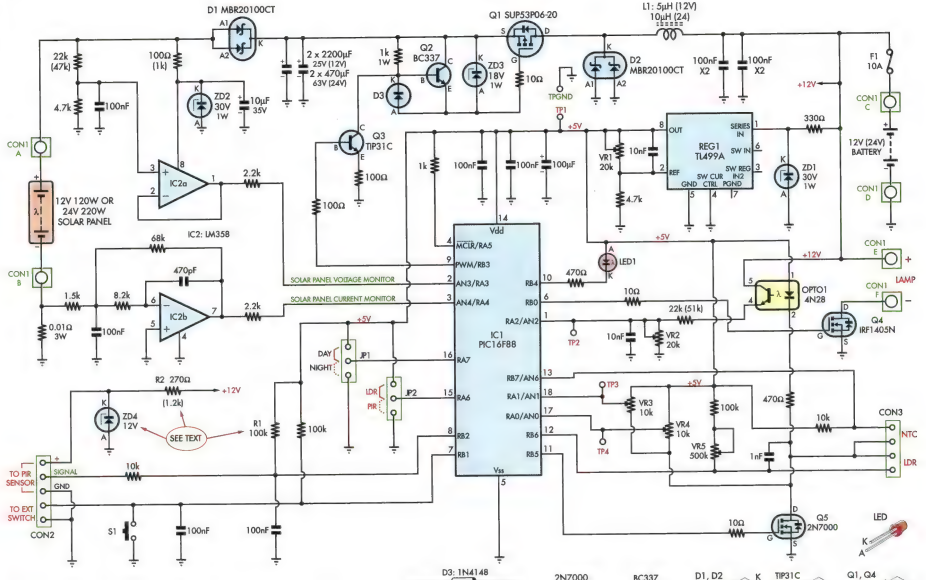
The NTC thermistor forms a voltage divider with a 10kΩ resistor across the supply when Q5 is switched on. IC1's AN6 input monitors this voltage and converts it to a value in degrees Celsius. At the same time, IC1's AN1 input monitors the setting of trimpot VR3.

This trimpot is effectively connected across the 5V supply when Q5 is switched on. The AN1 input voltage is converted to a mV/°C value and this can range from 0mV/°C when VR3 is set to 0V to 50mV/°C when VR3 is set for 5V.

Power saving

As mentioned, Mosfet Q5 connects trimpots VR3 and VR4, the LDR and the NTC to 0V and also powers the optocoupler LED. Q5 is powered on with a 5V signal from the RB5 output of IC1. The Mosfet then momentarily connects these sensors to 0V so that microcontroller IC1 can measure the values. When Q5 is off, these trimpots, sensors and battery divider are disconnected from the supply to reduce battery drain.

One problem with using Q5 to make the 0V connection for the trimpots, battery and sensors is that these sampled voltages cannot be easily measured



SOLAR CHARGE/LIGHTING CONTROLLER

Fig.6: the full circuit for the 12V/24V Solar Lighting Controller is based on PIC16F88 microcontroller IC1. This monitors the solar panel voltage and current signals from IC2, a PIR sensor (if used), switch S1, a light dependent resistor (LDR) and a NTC thermistor. The resulting PWM (pulse width modulation) output on pin 9 of IC1 then drives power Mosfet Q1 via transistors Q3 & Q2 to control the charge current for the battery, while Q4 controls the lighting.

Parts List: Solar MPPT Charger/Lighting Controller

1 double-sided PCB, code 16101161, 141 x 112mm
1 diecast box 171 x 121 x 55mm (Jaycar HB5046)
1 6-way PC-mount screw terminal block (Altronics P2106) (CON1)
1 3-way PC-mount screw terminal block, 5.08mm pin spacing (CON2)
3 2-way PC mount screw terminals 5.08mm pin spacing (CON2,CON3)
1 powdered-iron toroid 28 x 14 x 11mm (Jaycar LO-1244)
1 SPST PC mount tactile membrane switch with 3.5 or 4.3mm actuator (S1) (Altronics S1120, Jaycar SP0602)
1 10kΩ NTC thermistor (Altronics R4290, Jaycar RN3440 or equivalent)
1 LDR with 10kΩ light resistance, 1MΩ dark resistance (Altronics Z1621, Jaycar RD3480 or equivalent)
2 IP68 cable glands for 8mm cable
1 IP68 cable gland for 6.5mm cable
1 DIL18 IC socket
2 M205 PC mount fuse clips
1 10A M205 fast blow fuse (F1)
1 TO-220 U shaped heatsink, 19 x 19 x 10mm
1 M3 x 10mm machinescrew
4 TO-220 silicone insulation washers
4 TO-220 insulating bushes
4 M3 x 12mm machine screws
5 M3 nuts
2 3-way pin headers with 2.54mm pin spacings (JP1,JP2)
2 jumper shunts for pin headers
2 100mm cable ties
1 3m length of 0.5mm enamelled copper wire
1 50mm length of 0.7mm tinned copper wire (for PIR, see text)
4 PC stakes

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1610116A.hex (IC1).
1 LM358 dual op amp (IC2)
1 4N28 optocoupler (OPTO1)
1 TL499A regulator (REG1)
1 SUP53P06-20 P channel Mosfet (Q1)
1 BC337 NPN transistor (Q2)
1 TIP31C NPN transistor (Q3)
1 IRF1405N N-channel Mosfet (Q4)
1 2N7000 N-channel Mosfet (Q5)
2 MBR20100CT fast dual diode (D1,D2)
1 1N4148 diode (D3)
2 30V 1W zener diodes (ZD1,ZD2)
1 18V 1W zener diode (ZD3)
1 12V 1W zener diode (ZD4) (for 12V PIR, see text)
1 3mm high intensity LED (LED1)

Capacitors

2 2200µF 25V low-ESR PC electrolytic (12V version)
2 470µF 63V low ESR electrolytic (24V version)
1 100µF 16V
1 10µF 35V
6 100nF MKT polyester
2 100nF X2 class Metallised Polypropylene
2 10nF MKT polyester
1 1nF MKT polyester
1 470pF ceramic

Resistors (0.25W, 1%)

1 100kΩ (R1) – see text
2 100kΩ
1 68kΩ
1 47kΩ (24V version)
1 51k (24V version)
2 22kΩ (12V version)
2 10kΩ
1 8.2kΩ
2 4.7kΩ
2 2.2kΩ
1 1.5kΩ
1 1.2kΩ (use for 24V supply with 12V PIR see text)
1 1kΩ (24V version)
1 1kΩ 1W
1 1kΩ
2 470Ω
1 330Ω
1 270Ω (for 12V PIR, see text)
2 100Ω
1 100Ω (12V version)
3 10Ω
1 0.01Ω 3W resistor (Jaycar RR-3420)

Trimpots

2 10kΩ mini horizontal trimpots (103) (VR3,VR4)
2 20kΩ mini horizontal trimpots (203) (VR1,VR2)
1 500kΩ mini horizontal trimpot (504) (VR5)

Miscellaneous

1 12V or 24V SLA or $LiFePO_4$ battery
1 12V (up to 120W) or 24V (up to 220W) solar panel array
12V lamps suitable for 14.4V use
1 12V PIR (eg, Altronics S5314A)
10A cable, battery clips, shielded cable, heatshrink tubing

with a multimeter. This is because a multimeter will not capture the voltage when Q5 switches on momentarily. And we do need to measure some of these voltages for setting up.

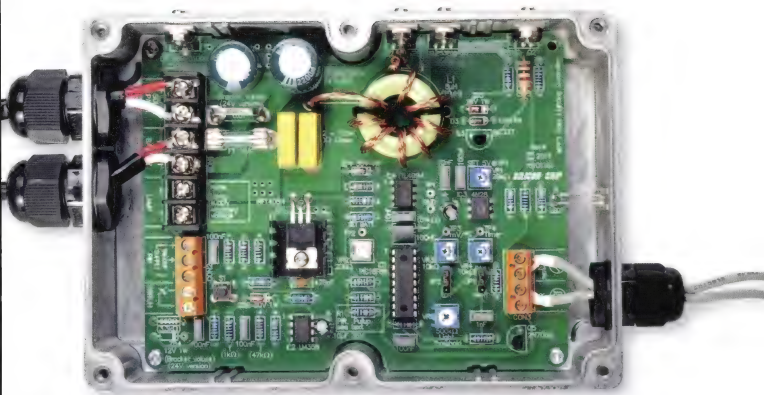
For example, we need to be able to set VR2 so that the battery divider is correct and we need to measure the timer and mV/°C values as set with VR4 and VR3. So in order to make these measurements, Q5 is switched on while ever S1 is pressed.

Other power saving techniques include driving the charge LED (LED1) from the solar panel instead of the battery. The only time this LED will light using battery power is if the thermistor is open or short circuit. In these cases, the LED flashes at a low duty cycle, again conserving power.

Op amp IC2 is also powered from the solar panel, because we only want to measure the solar panel voltage and current when solar power is available. Therefore, IC2 is fed via a 100Ω series resistor for a 12V panel and a 1kΩ resistor in the case of a 24V panel. Zener diode ZD2 limits the voltage to 30V.

Diode D1 prevents the battery from powering IC2 via Q1's internal diode and L1. The solar panel voltage is monitored using a 22kΩ and 4.7kΩ voltage divider, while a 100nF capacitor filters any transient voltages or noise that could be induced through long leads from the panel. IC2a is connected as a unity-gain buffer and its output is applied to the AN3 input of IC1.

As noted previously, current from the solar panel is measured by the voltage developed across a 0.01Ω shunt resistor. This is around 70mV for a current of 7A. The voltage developed across the shunt is negative and this is inverted and amplified by IC2b, which



Building the Solar Charger & Lighting Controller is easy, with all parts mounted on a single PCB. This is housed in a diecast metal case which provides the necessary heatsinking. The full assembly details are in Pt2 next month.

has a gain of -45. Therefore IC2b's output will be around 315mV per 1A of current from the solar panel. This output is applied to the AN4 input of IC1 via a 2.2kΩ current-limiting resistor.

Note that the actual calibration of voltage and current is not particularly important. The software within IC1 multiplies the voltage and current readings obtained at the AN3 and AN4 inputs to find where the maximum power point is for the solar panel

This calculation is not after any particular value but just the maximum in a series of power calculations. It does this calculation periodically (once every 20 seconds) and varies the on/off duty cycle of Mosfet Q1 to find the duty cycle that provides the maximum power from the solar panels.

Power for the remainder of the Solar Lighting Controller circuit comes from the 12V battery via REG1, a TL499A regulator. This is a low quiescent current type that can run as a linear step-down regulator and as a switchmode step-up regulator. We have used it as a 12V to 5V linear regulator, with the output voltage trimmed using VR1 to as close to 5V as possible. This then calibrates the analog to digital conversion within IC1, ensuring correct charging voltages for the battery.

Protection against reverse polarity connection of both the 12V battery and solar panel are included. If the solar panel is connected with reverse polarity, IC2 is protected because ZD2 will conduct in its forward direction, preventing more than 0.6V reverse voltage from being applied across its pin 4 and pin 8 supply rails. D1 prevents reverse voltage from the solar panel being applied to the remainder of the circuit. Finally, should the battery be connected back to front, D2 will conduct via inductor L1 and the fuse will blow, breaking the connection.

Next month, we'll cover full constructional details and set-up procedure. SC

SERVICEMAN'S LOG

Batteries need careful maintenance

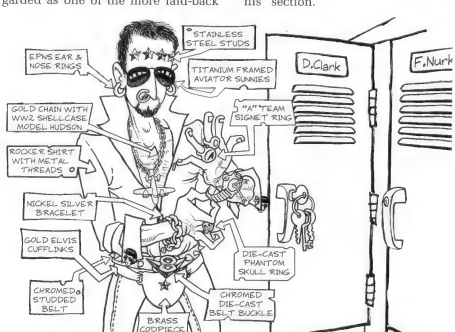
Dave Thompson*

Batteries used in aircraft must be carefully maintained, as I learnt during my time as an apprentice in NZ with our national airline. In that role, they undergo regular service checks but they are often the forgotten item in consumer electronic equipment where they are left to leak and cause all sorts of damage.

Many years ago, as a "wet-behind-the-ears" avionics apprentice, I spent some of my training time in a section of the engineering workshops colloquially called the "battery room". This part of the avionics department was separate from the main areas we were usually posted to, such as the instrument or radio shops, and although not totally isolated from the rest of the world, it was a bit off the beaten track in the hanger.

Because of this (and due to some other perks), the battery room was regarded as one of the more laid-back postings an apprentice could get, especially considering the pressure we were all under to cram in as much knowledge and experience as we could in our 10,000 hours of training (and regurgitate it all later during our various trade exams!).

The elderly engineer who ran the battery room at the time was well-known for his grandfatherly demeanour but he didn't suffer fools gladly. As a result, most apprentices were more than a little intimidated when it was their turn for a tour of duty in "his" section.



...IT WAS ENOUGH TO REMIND ME EVERY MORNING TO REMOVE WHATEVER "BLING" I HAPPENED TO BE WEARING AT THE TIME

Items Covered This Month

- Dave gets a charge out of batteries
- Battery-powered buggy repair: fixing "The Duck"
- Gas furnance repairs: persistence pays

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The battery room actually consisted of two rooms; one for lead-acid batteries and one for nickel-cadmium types, both flavours being used in different aircraft in the fleet at the time. These rooms were right next door to each other but separated to prevent cross-contamination. To that end, there were two sets of tools and other gear, along with machines, jigs and safety equipment specific to the types of battery in each room.

Not many people realise that batteries are used in large aircraft. However, the set-up isn't like the system used in cars, where there is one 12V lead-acid battery whose main task is to power the starter motor to start the engine.

On the contrary; although there are typically one or two main batteries in larger aircraft, they are rarely used to start the engines. Instead, a GPU (Ground Power Unit) is usually plugged into an aircraft with electric starter motors and this unit can usually be observed connected via a heavy-duty cable into the side of the plane during the start-up procedure. It's then removed (hopefully!) before the plane leaves the apron.

If no GPU is available, the on-board battery can supply enough "juice" to start an engine though once that engine is up and running, power (or air pressure if it is that type of starter) generated by the first engine is then used to start any others.

Apart from that main battery, which is typically a 24V unit, there could be literally hundreds of other batteries (of various types) on board. You can find batteries in everything from emergency lighting to torches and radio beacons and, of course, there are also batteries in the so-called black boxes; the flight data recorders that are actually painted Day-Glo orange to make them more visible. What's more, due to the superior battery technology that's been developed since I worked for the airline, there would be even more battery-powered devices used in planes these days.

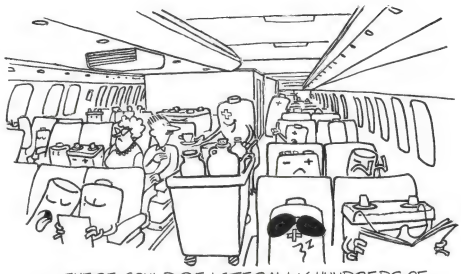
Watches were verboten

When a new guy turned up for his first day in the battery room, the first thing the old engineer did was to ask for the time. The unwary apprentice, thinking he was doing well because he'd turned up 10 minutes early in order to make a good first impression, would then look at his watch to proudly announce his punctuality only to be shot down for breaking one of the cardinal rules of the battery room: no watches or jewellery allowed!

While jewellery of any type was actively discouraged in all the different engineering sections, for obvious (and not so obvious) reasons, it was completely banned in the battery room. Batteries and metal don't mix all that well and getting a watch band or ring across one or more of the exposed cell links of a Nicad or lead-acid battery could really ruin your day. Indeed, the image of a white-hot ring melting the finger it was attached to it was enough to remind me every morning to remove whatever "bling" I happened to be wearing at the time.

And the rules didn't stop there; the airline was always fastidious about safety and you had to wear the appropriate gear for the job. What's more, there was none of that typical "macho-bullying" I'd observed in other workplaces, where people were called all manner of derogatory names just for wearing ear-muffs, gloves or safety goggles.

It was the exact opposite at the airline; the various foremen around the hangar didn't take any rubbish safety-gear wise, especially from apprentices who, by their very nature, sometimes thought they knew everything! It was very simple – you either wore the correct safety gear or you didn't get to work there.



~THERE COULD BE LITERALLY HUNDREDS OF OTHER BATTERIES (OF VARIOUS TYPES) ON BOARD

I really liked that workplace spirit; I've met too many people suffering from industrial deafness to forego wearing ear-muffs and I know one guy who lost an eye when a hammer he was using chipped. He'd still have both eyes if he had been wearing goggles!

Aircraft batteries

The aircraft batteries I worked with were high-capacity types made up of individual cells. A typical 24V Nicad battery consisted of twenty 1.2V cells all linked together in series and arranged so that they'd all fit neatly into a relatively-compact steel container. The links tying all these cells together are made of heavy-gauge steel and are torqued to a specific value before being coated in a jelly-type substance to reduce corrosion.

As you'd expect, the tools used on these batteries were specialised and well-insulated and that brings me to another rule that was enforced: no outside or "foreign" tools were to be used in the battery room. In fact, the old engineer liked to bring out three examples of tools that had fallen foul of batteries to illustrate what could happen if we were careless. One was a crescent (or shifting spanner in Australia) and the other two were sockets but you could barely recognise them as the original tools.

My guess is that they would have made a very impressive display as they were transformed and I remember clearly thinking I didn't want to be the guy associated with adding another melted tool to the rogue's gallery.

Although insulated tools certainly helped, the real key to battery maintenance was due diligence. In short (no pun intended), you needed to pay full attention when working on or around batteries. Each cell might only be 1.2V but it could deliver a huge amount of current and if you got something metal across a few of them, you could end up with up an explosive situation and another ruined spanner!

Regular testing

Like all aircraft components, batteries have a finite life cycle and endure a regular testing schedule during that time. If a cell started failing, it was replaced as soon as any anomalies were detected. A battery didn't have to spend any particular amount of its scheduled time between checks in an aircraft either; even if it sat on a shelf awaiting use, it still regularly came back to the battery room for the usual capacity and leakage tests.

These tests typically entailed hooking the battery up to what was then a very advanced battery/cell analyser that would discharge the cells at a given load current. In practice, the battery's cells were manually (and very carefully) connected to the analyser using 20 large insulated alligator-type clips. Once the test started, an engineer would carefully monitor each cell as it discharged. Any cell that didn't make the grade was replaced, thereby keeping the battery up to specification.

Once a cell had been in service for a certain number of hours, regardless as to whether that time was spent on the shelf or in an aircraft or whether it passed the tests or not, it was re-

I START BY SLIPPING ON PROTECTIVE GLOVES

placed and discarded. This meant that there was an almost-constant supply of some of the best-quality Nicad cells money could buy available to those who wanted them.

And people really did want them, including boaties, modellers, campers, car-guys, solar-energy buffs and hobbyists. Anyone who wanted cells could put their names down on a list, which made the battery room guys very popular. We were especially popular on winter days when car batteries would go flat and a jump-start was required.

In fact, we had a specially made starter-pack for just this purpose and I made some good inter-departmental relationships that way. It was always handy to get to know the people in the stores or the machine shop, or the paint shop – you get the idea. It seems a bit silly now after all these years but those life-expired Nicad cells were highly sought after at the time and probably still are.

The lead-acid batteries, of course, had a completely different life cycle and maintenance schedule. They were also assembled differently and thus needed different tools, test gear and handling. They probably don't use them at all now but back then they were used on some of the older planes in the fleet and life-expired lead-acid batteries were also very popular with the spot-lighters and boaties.

As can be imagined, we also had to take care of the acids and electrolytes for these batteries. We made up the mixtures ourselves in the lead-acid room in a huge, hard-plastic vat specially made for the job. To get the right specific gravity, we had to weigh bags of concentrated acid crystals and then add them to distilled water until we got it just right (distilled/purified water was another prized perk from the battery room due to the large purifier/distiller we operated there).

Unfortunately, the first time I did this, things didn't quite work out as planned. After getting dressed up in all the safety gear and going through the mixing procedure, the result was an evacuation of the hangar!

It wasn't actually my fault; well, not entirely. I was with the base foreman at the time and he was showing me the ropes. We did everything as it was always done and when I added the crystals, I poured them into one big pile in the middle of the vat, as I was instructed to do. As we started stirring the mixture with large wooden paddles, I noticed that the water level appeared to be dropping. I mentioned this to the foreman and he suddenly looked very concerned.

The floor in both battery rooms consisted of concrete covered in a layer of anti-static, plastic duck-boarding and we had to peer carefully through the gaps in the boards below the vat to confirm our fears; there was an increasing pool of partially-mixed acid spreading underneath. At that point all sorts of protocols had to be followed and this in-part entailed noisy alarms and an evacuation of that section of the hangar.

This resulted in about 100 engineers standing out in the car park, grumbling and cursing all apprentices. A subsequent investigation found that the acid's chemical reaction with the water caused so much heat to build up in the pile that had it melted through the bottom of the vat. Over the years, this vat had gradually thinned out with use and it was just my luck that it finally failed on the day I was the one mixing the electrolyte.

As I said, it wasn't really my fault! In any case, I didn't get into too much trouble for it but working in the battery room did give me a healthy respect for batteries and what they can do.

Recent jobs

Where's all this leading to? Well, just recently, I had a run of jobs through the workshop that involved batteries. The first was a trail camera that had been stored with its batteries inside it and they had eventually leaked, corroding part of the circuit board. I rebuilt it, replacing damaged components and PCB tracks in the process, and it all worked again.

Fortunately, I could see what the components were and could replace them. However, some jobs aren't as clear cut as that.

For example, a customer recently brought in an older-style radio, probably from the late 70s to early 80s era. It was a beautifully-made multi-band portable model that used to be all the rage and I recall that this particular model was advertised in all the magazines of the day.

As with the trail camera, the owner had stored it with the batteries inside it and they had eventually leaked and made a real mess. Since they don't make radios quite like this any more, the owner wanted to know if I could do anything with it. I told him what I tell all clients in this position; that I'd clean it up and repair it as best I could but the reality is that the material leaking out of most batteries is corrosive and it could have ruined things beyond repair.

As with any battery-damaged device, I start by slipping on protective gloves (I use heavy-duty nitrile mechanic's gloves). I then place a rag on the bench

to protect it from what I'm working on. That done, I remove the batteries from the device but I don't just chuck them in the bin, as many servicemen probably do. Instead, I put them aside for when I go to the refuse station, where I can dispose of them in the hazardous materials container.

This particular radio used four C-size cells in a plastic battery holder and the whole assembly was covered in nasty sludge. As a result, I simply cut the wires from the holder and put the lot in a zip-lock bag, ready for disposal. I already had a new holder sitting in my parts drawer, so I could afford to lose this one and not spend time trying to clean it up.

Unfortunately, the leaked material had also contaminated the circuit board in a couple of areas. I made up a solution of vinegar and water and scrubbed the affected area with an old toothbrush, then used isopropyl alcohol to further clean up after that.

A few PCB tracks in the affected area had been corroded but were electrically still intact. However, some tracks had been eaten away completely. These were repaired using two "twisted-together" strands of wire pulled from hook-up wire, with the strands following the original track path where possible.

Once everything had been soldered into place and the cells replaced, I checked the radio out and it worked perfectly. I then finished the job by mixing up some 5-minute epoxy and applying a thin layer over the repaired area on the PCB. That should protect the repairs and hopefully last the life of the radio.

Another similar job involved a pair of leaking AAA Nicads in a remote control. This remote was for a vintage Japanese CD player and the device couldn't be operated properly without it.

As with the previous two jobs, the cells had leaked onto the circuit board and so the remote no longer worked, even with fresh batteries. This time, after removing the PCB, I used a solution of bicarbonate of soda to neutralise and clean up the chemical spillage. In this case, no tracks had corroded but a small capacitor had come away from the board. Unfortunately, there were no leads left on this capacitor and no markings were visible but it looked very much like a 10nF capacitor I had in my parts bin.

After soldering it in and reassembling the unit, I tested the remote by looking at it via the viewfinder of my Sony Handicam. Sure enough, there were flashes on the viewfinder's screen each time a button was pressed, indicating that the remote's infrared LED was working (this technique also works with digital cameras, including those on smart phones).

When the customer subsequently brought his CD player around, it all worked perfectly, so chalk up another success. However, I have to admit that this was more a case of blind luck rather than skill.

And the moral of this story: always remember to remove the cells when storing or not using battery-powered devices for some time. It's a lot easier than cleaning up after a leak!

Battery-powered buggy

If it walks like a duck, quacks like a duck and has feathers like a duck, then you've probably got a duck. G. M. of Pukekohe, NZ recently got a duck going again but this one didn't quack and had wheels instead of feathers . . .

Over the last 15 years, my work has changed from domestic audio and video appliance repairs to mostly light industrial electronic repair work. However, I still do domestic work for my more senior clients who can't bring themselves to throw out stuff which has given 20 years of service because it "must still have some life in it". That said, I try to restrict such work to appliances which are expensive to replace, such as large-screen TVs and quality hifi equipment, or items which are not readily replaceable such as the odd VCR, 8mm projectors and good-quality turntables.

The fate of pretty much everything else is often decided when I point out that a non-refundable deposit is required before any work is commenced. In the end, wisdom usually prevails and the deposit is instead invested in a new appliance. Sure it means doing myself out of a few dollars on such occasions but there's no point trying to service cheap "stuff". Retaining my sanity is much more important, especially since the older I get, the less of it I seem to have!

My light industrial work includes supplying, installing and servicing PA systems, band equipment, background music sound systems, battery chargers which may be specific to a piece of equipment and motor controllers which may be difficult or expensive to replace. Now that the word is around that I take on that type of work, it just keeps coming in.

One thing that has allowed me to attempt such repair work is the internet. Since many items that come in the door are not very common (and often it may be the first and last time I'll ever see one), a quick assessment is required to determine whether the job is likely to be viable.

It never ceases to amaze me what can be mined from the internet, the list including schematics, spare parts sources and snippets of useful information from discussion forums. Within an hour or two of opening up an item, I can usually provide the owner with an assessment and I'll either give a "ball-park" estimate as to the repair cost or I'll "pull the pin" on the job and give the equipment back with an invoice for my time.

I currently do a lot of regular repair work for a large glasshouse which covers several hectares. Middle management staff have bicycles at their disposal to efficiently move around the complex. However, the maintenance man often needs to lug tools and equipment with him and may need to travel half a kilometre within the glasshouse to get to the job at hand.

In view of that, a bicycle was hardly practicable so the company purchased a second-hand battery-powered buggy. This machine had been imported from the UK many years before and no-one is sure of its past life. Some think it may have been a golf-cart, while others think it may have been an airport baggage tug. I'm more inclined to think

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Gas furnace repairs: persistence pays

Now for something completely different – central heating furnaces. D. M. of Box Hill, Victoria has solved a few problems with these furnaces, often saving a perfectly good unit from the scrapheap . . .

It is often said that "they don't make them like they used to". That's often true and while modern technology is more advanced, today's manufactured products often have short lifetimes because they are designed to be replaced before they start to wear out and require repair. Older products, on the other hand, can often be inexpensively repaired and kept going for a very long time.

In Victoria, many homes have gas-fired ducted central heating. In this system, a central furnace heats incoming air and it is then distributed about the house through ductwork.

The furnace consists of gas burners with spark ignition (or a pilot light in older systems), a heat exchanger to heat the incoming air (using a gas flame and a plenum chamber to collect the heated air), a blower to distribute the heated air, a gas control valve and safety features such as a flame sensor to ensure no gas is released if there is no flame. There is also an external thermostat connected to the gas control valve to control the temperature, usually by turning the gas flame and blower off and on as necessary.

Overall, gas central heating furnaces are relatively simple devices and the main components that might need replacement such as the gas control valve and thermostat are often standard items and not specific to a certain brand.

Over the years, I've had several experiences with the repair of these units. The first was when a female friend told me that her central heating had not worked for years. As a result, she had placed expensive-to-run electric heaters in all rooms to keep warm.

It turned out that she had been told by a licensed repairer that her 20-year old furnace needed replacing at a cost of around $7000. I looked at the heater and it seemed to be functioning but very little air was coming out of the vents. I then noticed that the return air-duct filter had been completely blocked with dust and once that had been cleared, it functioned perfectly.

The second experience was when a heater on my own property stopped working. The blower had stopped operating and so warm air wasn't being circulated and the unit was shutting down as a safety measure. When told the age of the unit, several licensed repairers refused to even look at it and said simply that the entire unit would need to be replaced at a cost of about $3000.

Despite being built in 1970, the unit appeared to be in sound condition. In the end, I decided to take a look at it myself. I soon determined that the fan blower bearings had seized and after replacing them, the unit worked perfectly again.

It continued working until it developed another problem about 20 years later. This time, the flame wouldn't come on at all as no gas was being released into the burners. Again, the licensed repairers I contacted weren't interested in looking at such an old unit so I again decided to see what I could do.

The problem this time was a faulty gas control valve. This is a standard Honeywell unit and costs about $300 from local suppliers. In the end, an equivalent modern model was purchased via eBay from the USA for about $110 delivered. A plumber friend then installed the valve as gas work requires a license.

The unit again works perfectly and is expected to do so for many more years to come.

My third experience relates to another friend who has a central heating furnace, again about 20 years old. As before, numerous licensed repairers would not look at the unit and told him that it would need replacing.

This friend is a qualified electronics technician and he quickly determined that the gas control valve was faulty. I discussed the problem with him and helped track down a source for the spare part. His problem now is to find a licensed technician prepared to install it for him.

A fourth experience involved a furnace on a different property of mine. An electronic control module failed and replacement units were about $300. This module isn't hard wired but is connected via terminal blocks and so is easily removed.

A Melbourne company called the "Module Repair Service" (www.modulerepair.com.au/) repaired the module for less than $100 and it's

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the latter as it is a three-wheeled vehicle with a tow bar and I don't think it would have been very stable on even the more gentle slopes of a golf course let alone the more-rugged verges where my ball usually ends up!

Whatever its history, it had been a reliable tool of the business for many years now and is affectionately referred to as "The Duck" due to its appearance. Recently, however, it decided to quit. One minute it was working and the next minute it just stopped, with no power to the electric motor despite the gauges indicating that the battery had sufficient charge.

I was not completely unfamiliar with "The Duck", having done some basic work on the steering column controls a couple of years earlier, so that apparently "qualified" me to tackle this new problem. When I arrived, "The Duck" was plugged into its charger, so I unplugged it and lifted the seat and housing clear to access the batteries and electronic circuitry.

Power for the buggy is provided by two banks of deep-cycle cells, each bank consisting of 12 x 2V cells, thus giving a total of 48V. This all sits in a steel box, the volume of which would be equivalent to eight medium-sized car batteries, so it is a store of considerable energy. The batteries are almost certainly the originals and are at least 20 years old, so they have given good service. However, they are now starting to look a bit weathered.

When I last serviced "The Duck", I checked the batteries and found that most of the cells required quite a large top-up of distilled water. In fact, some

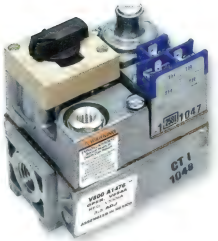
now better than new. That's because they are familiar with its failure modes and they replace both those parts that have failed and those that are likely to fail with uprated parts. After the repair, the furnace worked perfectly.

A final experience was with a large installation at a school. It had a 1960s furnace that was originally fuelled by oil but had later been converted to gas and it circulated hot water to radiators in the classrooms. It was of massive cast-iron construction and different to the types of furnaces discussed above.

Several licensed technicians advised that the unit was unrepairable and had to be replaced at a huge expense. Eventually though, we managed to find a company that was prepared to take the job on. Their licensed technicians repaired the furnace by replacing defective fire bricks and the furnace was safely fixed.

In summary, repairing these central heating furnaces can often be both simple and inexpensive and there is usually no need to replace the unit at great expense. Unfortunately though, many licensed repairers seem to have no interest in simple and inexpensive repairs and simply recommend replacement of the entire unit. One wonders how many people have spent thousands of dollars to replace a furnace when a repair could have been done for hundreds of dollars.

Finally, a word of warning: for obvious safety reasons, gas furnace repairs should only be carried out by a licensed technician. If such work is required, persist until you find a repairer prepared to do the work rather than replace the entire unit.



A Honeywell gas control valve similar to the replacement unit (the original 1970 part number was not available but this is an equivalent unit). A licensed plumber is required to install this part but most technicians are not prepared to do such a basic repair on older equipment.

This Brivis TEK321 ducted heater controller was repaired using uprated components, making it better than new. A qualified technician was eventually found to replace this part as well.

consumed close to a litre, so they had been somewhat neglected. I brought the importance of regular battery checks to the maintenance man's attention at the time and left it at that, as the batteries otherwise seemed to be in good order.

The first thing I did now was to check a few of the cells and I found that they were all nicely topped up. However, this may have just been done before I called, to avoid a good-natured ribbing from me. I'll never really know, of course, but I have my suspicions.

The next step was to check the battery voltage and it read exactly 48V, so all appeared to be OK there. In hindsight though, this was the first big clue as to what the fault might be but I missed it!

After jacking the machine clear of the floor, I popped the lid on the control circuit box and, following a quick visual check, turned on the power and prepared to carry out a few tests. A minute or so later, the direction solenoids began to intermittently chatter and buzz, sometimes pulling hard on and at other times almost but not quite getting there. However, they should not have been operating at all yet, let alone both at once.

Normally, these solenoids operate one at a time in order to reverse polarity to the motor for forward or reverse direction – and then only just before a drive signal is applied to the gates of a bank of heavy-duty Mosfets which control the acceleration. In this case though, pressing the accelerator had absolutely no affect.

I prodded and poked around the control PCB without result, which suggested that it wasn't a dry joint or connection issue. Instead, it seemed that something in the circuit was producing a severe amount of random noise, because the voltages around the solenoid drive transistors were fluctuating wildly. By now, the battery voltage had dropped a volt but that seemed insignificant as it was now powering the control circuitry, etc.

Unfortunately, the conditions I was working under were far from ideal due to poor light and background machinery noise. I was also working in a stooped position and lacked suitable test equipment for tracking down such a fault. As a result, I powered everything down and removed "The Duck's" control module for closer scrutiny back in my own workshop.

The next day, I connected dummy loads and applied power to the control module on the bench and carried out a few tests. The first obvious thing was that there was no longer any of the sporadic activity from the solenoid drivers which I had experienced the day before. I tried prodding various parts and varying the temperature and the supply voltage but all to no avail. No matter what I did, I couldn't induce the symptoms to reappear.

Convinced that some component had been in its death throes the day before but was now holding out on me, I connected an audio signal tracer to see if I could pick up any noise in the circuitry. Even though I was technically "listening" to DC voltages, I have found this procedure to be useful in the past for tracking down noisy components which, of course, generate an AC signal in the form of random static.

In this case, I seemed to be getting noise everywhere but not high enough to cause the problems I had experienced the day before. Eventually, after

continued on page 96

PRODUCT SHOWCASE

New Scope Rider from Rohde & Schwarz: five instruments in one

Rohde & Schwarz claim their new Scope Rider series (being shown for the first time at this month's Nuremberg Embedded World Trade Fair) is the first handheld oscilloscope with the functionality, touch and feel of a state-of-the-art lab oscilloscope. The R&S Scope Rider is based on a high-performance oscilloscope but can function as a logic analyser with eight additional digital channels, as a protocol analyser with trigger and decoding capability, as a data logger and a digital multimeter.

Its rugged design makes it ideal for mobile installation and maintenance work. The instrument features isolated input and communications interfaces. It meets CAT IV standards and can carry out measurements on low-voltage installation sources up to 600V.

With an acquisition rate of 50,000 waveforms per second, a 10-bit A/D converter and a maximum bandwidth of 500MHz for the analog input channels, this portable oscilloscope clearly outperforms comparable instruments.

The R&S Scope Rider will be available as a four-channel or a two-channel instrument, the latter with a digital multimeter, with bandwidths of 60MHz, 100MHz, 200MHz, 350MHz and 500MHz. There will be trigger and decoding options available for I^2C, SPI, UART, RS-232, RS-422 and RS-485 at the time of market introduction.

Contact:
Rohde & Schwarz (Aust) Pty Ltd
Suite 2/2 Compark Circ, Mulgrave, Vic 3170
Tel: (03) 8874 5173 **Fax:** (03) 8874 5199
Web: www.rohde-schwarz.com.au

How do you buy US-only products in Australia/NZ?

The Amazon Echo (pictured) was one of the Christmas 2015 gun products . . . but it was not sold in Australia or New Zealand.

A few canny people were able to obtain this (and other) products which have only been released in the USA by using a New York company called Big Apple Buddy. They're a shopping concierge service which buys local product and ships them direct to you via Fedex, UPS or DHL.

They have a minimum service fee of $US40 per order, which covers all the leg work required to source, negotiate prices, packing and shipping your purchase.

The process is extremely easy and all costs are set out in a free quote which you receive prior to purchase.

For more information, visit www.bigapplebuddy.com

"CheckmyTemp" Thermometer Crowdfunding target passed

Elsewhere in this issue we feature a successful crowdfunding campaign for the "Joey" Arduino display.

Here's another: "CheckmyTemp" has now passed its target and will go into production. It's the world's most advanced thermometer, worn as an armband, whose embedded sensors accurately monitor the wearer's body temperature, position and movement.

Data is then transmitted to a handheld display for either immediate action or later evaluation. It's claimed that this will save the lives of countless thousands of people, especially children, and those with epilepsy (where a spike in temperature can give an indication of an imminent seizure).

More information on the device can be found at www.indiegogo.com/projects/check-my-temp

FreeviewPlus set-top box from TEAC

While most Australians have access to the Freeview (ie, free-to-air) TV channels, many are confused as to how and where to receive them.

The new TEAC HBBTS1 set-top box is specifically made for FreeviewPlus. It's compact and easy to set up and comes with built-in internet connectivity. It can also record free-to-air programs to a USB drive, so that viewers never have to miss a thing.

FreeviewPlus uses hybrid TV technology, which seamlessly combines broadband and broadcast TV, delivering the Freeview networks' catch-up services all in one place – on the TV. Access to catch-up and other services is easy, with viewers simply using the coloured buttons on the remote control.

The TEAC HBBTS1 set-top box is available nationally at Betta Electrical, The Good Guys and Harvey Norman.

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Pre-built Dual Filament 3D Printer TL-4090

NEW $1399

Capable of printing with two colours and/or materials simultaneously. This printer does not require a computer in order to print and is ideally used as a stand alone unit, printing files from a SD card. Printer provides a heated bed and generously sized glass plate to print up to 298 x 160 x 130mm.

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- Compatible with ABS, PLA filament material
- 465(W) x 315(H) x 390(D) mm

FREE 1KG BLACK 3D FILAMENT FOR NERD PERKS CARD HOLDERS TL-4070

TL-4070 VALUED AT $49.95

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90W Automatic Mini Car Laptop Power Supply MP-3334

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Fused Cigarette Lighter Plug to 2.1mm DC Plug PP-2008

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Lighter plug has 5A 3AG fast blow fuse and red power indicator LED.

IT POWER SUPPLIES

NEW

6 Way USB Powerboard MS-4068

$39.95

Charges up to 6 USB devices at a time and features a smart charging IC.

- Current Output: 2 x 2.4A ports, 2 x 1A ports or 4 x 1.2A ports, 2 x 1A
- 190(L) x 40(W) x 32(H)mm

SATA/IDE to USB 2.0 Hard Drive Adaptor XC-4150

$44.95

Perfect tool to backup or transfer large amounts of data from one drive to another. Includes one touch back up and can support up to 3 hard drives simultaneously.

USB to DVI Adaptor XC-4879

$79.95

Enabling the addition of up to six extra displays, this adaptor allows you to add high-resolution graphics without having to add a graphics card - just connect it to any USB 2.0 port. Ideal for gamers, conference or AV rooms, POS systems or industrial applications.

3D Pen TL-4050 WAS $129

NOW $99 SAVE $30

Construct 3D objects in a more natural way. The pen will melt the inserted plastic and produce a thin extrusion that hardens quickly allowing you to draw a 3D object. No size limitations.

ARDUINO® KITS, SHIELDS AND ACCESSORIES - SEE PAGE 6 & 7 FOR MORE!

NEW

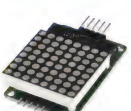
DOUBLE POINTS

750W 1500VA Line-Interactive UPS

$299

WITH USB MP-5216

Protect your valuable computer system and critical data from black-outs, brown-outs and power surges. Supplied with a USB interface cable and software. This UPS also features 2 x USB sockets on the front for charging any USB devices.



Arduino® Compatible 8 x 8 LED Dot Matrix Module XC-4499

$7.95

A 64 x red LED matrix, this module is easily controlled with the LedControl library. Display your own custom characters, or chain multiple modules together to make a scrolling display.

- 62(W) x 32(H) x 14(D)mm

DuinoTECH Classic (UNO) XC-4410

$29.95

ATMega328P Microcontroller. Powered from 7-12VDC or from your computers USB port. 5VDC Regulated via USB port or 5V pin.

- 75(W) x 53(L) x 13(H)mm

SEE PAGE 6 FOR AN EXCITING NEW ARDUINO® DIY PROJECT

Arduino® Experimenters Kit XC-4262

$89.95

Learn about the exciting world of Arduino® with these easy to build projects. From flashing LED to moving things with a servo. Complete with instructions and a supporting web page and software examples. No soldering required.

IT ESSENTIALS

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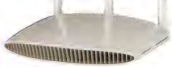

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A small device that plugs into the USB port of your computer to provide a faster charge to a Smartphone or Tablet. The intelligent circuitry within this booster detects the device connected and automatically switches to the full speed charging mode up to 2.1A.

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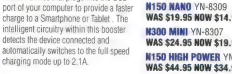

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YN-8360 YN-8365

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NOW $89.95 SAVE $10

Wi-Fi Extenders

Turn a 'dead spot' into a Hotspot simply by placing the extender between the router and the tricky area. 3-in-1: extender, access point & bridge.

SINGLE BAND 802.11 b/g/n. 300Mbps. YN-8360 **WAS $69.95**

DUAL BAND AC750. 2.4/5GHz. 300/433Mbps. YN-8365 **WAS $99.95**

NOW $89.95 SAVE $10

USB 3.0 TO HDMI ADAPTOR

XC-4973 **WAS $99.95**

Add another monitor or projector to your PC via USB. Full HD 1080p. Streams video & audio via HDMI to your additional display.

YN-8352

FROM $99 SAVE UP TO $20

Powerline Network Extender Kits

Extend your network using your mains power line. 10/100Mbps, overload protection. Single port.

EXTENDER YN-8352 **WAS $109 NOW $99 SAVE $10**

EXTENDER + WI-FI HOTSPOT YN-8356 **WAS $179 NOW $159 SAVE $20**

FROM $27.95

XC-4834

RS-232 DB9M Converters

Connect a variety of RS-232 devices to your modern computer with these adaptors.

TO USB ADAPTOR XC-4927 **$27.95**

TO USB 1.5M XC-4834 **$29.95**

$39.95

USB to Parallel Bi-Directional Cable

XC-4847

This cable allows you to print to most parallel printer devices through your computer's USB port. The device replicates the old 25 pin printer socket and provides up to 12Mbps data throughput, so printing is significantly faster compared with standard a parallel port connection. Plug & Play support.

$79.95

RS-485/422 to USB Converter

XC-4132

Wire up an RS-485/422 device to the 4 socket terminal block to give your hardware USB connectivity.Surge protected. Suitable for industrial, military, marine, science and custom built applications.

- 610mm USB A male to male cable supplied.
- Includes a 610mm USB A Male to Male cable
- Compatible with Windows 8.1, 8, 7, Vista, XP, 2000, Mac OS® 9.0+, and Linux
- 55(L) x 42(W) x 24(H)mm

DOUBLE POINTS FOR NERD PERKS CARD HOLDERS ON THESE PRODUCTS

PL-0978

FROM $4.95

DOUBLE POINTS

Serial ATA Cables

A range of SATA data and power cables for use with computers and external serial ATA devices.

SATA TO SATA DATA PL-0978 **$5.95**

HDD POWER TO 2 X HDD PL-0750 **$4.95**

HDD POWER TO 2 X SATA PL-0759 **$7.95**

DOUBLE POINTS

$38.95

SATA to USB 3.0 Adaptor

XC-4149

A simple way to access files temporarily on a SATA hard drive you no longer have installed. Includes USB 3.0 cable and mains adaptor.

DOUBLE POINTS

$49.95

3.5 SATA HDD Enclosure

USB 3.0 XC-4667

Easy installation, just two screws to remove the back panel and no internal cables. Supplied withUSB 3.0 cable and mains adaptor

FROM $49.95

DOUBLE POINTS

XC-4697

USB 3.0 SATA HDD Docks

Easily backup and store gigabytes of data quickly. Suits 2.5"/3.5" SATA HDD's (not included). USB 3.0 cable and power supply included.

SINGLE XC-4696 **$49.95**

DUAL XC-4697 **$69.95**

SINGLE CLOUD DOCK XC-4691 **$59.95**

DATA LEADS AND ADAPTORS

WC-7702

FROM $9.95

USB 2.0 Extension Leads

USB A Male to A Female leads to extend the range of your PC peripherals.

1.8M WC-7702 **$9.95**

3.0M WC-7703 **$11.95**

WC-7774

$14.95

USB 3.0 Leads

High quality data leads providing 10 times faster speed than USB 2.0 leads. 1.8m long.

USB A MALE TO A MALE WC-7770

USB A MALE TO B MALE WC-7772

USB A MALE TO MICRO-B MALE WC-7774

FROM $24.95

XC-4839

Active Extension Leads

All units feature built-in extenders to run your USB devices over longer distances with minimal signal errors.

USB 2.0 5M XC-4839 **$24.95**

USB 3.0 5M XC-4126 **$34.95**

USB 2.0 10M XC-4120 **$39.95**

USB 2.0 20M XC-4124 **$49.95**

$14.95

NEW

Rugged RJ45 Connector Plugs

PP-1453

Has been designed for use in harsh environments. Rated to IP67 it is dust tight and water tight making it handy for control and communications applications located outdoors or in industry workshops.

ALSO AVAILABLE:

RUGGED RJ45 CONNECTOR WATERPROOF CAP PP-1455 **$9.95**

FROM $9.95

RS232 Serial Cables

Variety of DB9 and DB25 serial cables to suit your applications. 1.8m long

DB9 MALE TO DB9 MALE WC-7535 **$9.95**

DB9 MALE TO DB9 FEMALE WC-7534 **$9.95**

DB25 MALE TO DB9 FEMALE WC-7516 **$11.95**

$29.95

USB RJ45 Extension Adaptor

XC-4884

Connect USB devices to a computer from up to 50m away via a standard Cat 5 network cable (sold separately).

- PC and Mac compatible
- Supports USB 1.1
- Transmitter and Receiver included

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE & BE REWARDED WITH A $25 REWARDS CASH CARD ONCE YOU REACH 500 POINTS! *Conditions apply. See website for T&Cs.*

SIGN-UP IN-STORE OR ONLINE TODAY BY VISITING: www.jaycar.com.au/nerdperks

WORK BENCH SPECIALS

15% OFF*

ALL SOLDERING STATIONS, IRONS & TIPS

10% OFF*

ALL NON-CONTACT THERMOMTERS & SOUND LEVEL METERS

$14.95

SAVE $4

32 Piece Precision Driver Set

TD-2106 **WAS $18.95**

Ideal for jewellery, model making or electronics. Tactile handle with extendable hardened shaft. Slotted, Phillips, Pozidriv, Torx and Hex pieces.

$26.95

30 Piece Tool Kit

WITH CASE TD-2166

Minor DIY repairs are a breeze with this 30 piece tool kit and every DIYer should have one of these in easy reach. The tools are held securely in a zip-up case.

TD-2451

FROM $29.95

SAVE $5

ROTARY TOOL KITS

Drill, saw, sand, polish, carve or grind.

110 PIECE TD-2451
WAS $34.95 NOW $29.95 SAVE $5

210 PIECE TD-2459
WAS $49.95 NOW $44.95 SAVE $5

SOLDERING TOOLS

NOW $19.95

SAVE $5

Soldering Iron Starter Kit

TS-1651 **WAS $24.95**

Includes all soldering essentials for various projects. Pack includes 240V 20/130W turbo soldering iron; spare tip, stand; solder; metal solder sucker with spare tip and O-ring.

NOW $50.95

SAVE $5

40W Temperature Controlled Soldering Station

TS-1620 **WAS $59.95**

It comes with a lightweight iron with anti-slip grip and tip cleaning sponge, with temperature adjustment up to 450°C. With 4mm banana socket connected to mains earth.

NOW $84.95

SAVE $15

Soldering Station

TS-1564 **WAS $99.95**

Lightweight soldering pencil with ceramic heating element and accurate analogue temperature adjustment. 240V, 46W.

NEW

NOW $169

SAVE $30

Portasol® Plastic Welding Kit

TS-1330 **WAS $199**

Cordless kit for plastic welding featuring an ultrasonically welded gas tank for better strength and reliability. Easy to use even for beginners with a simple click to ignite Piezo system.

MEASUREMENT TOOLS

Cat II Autoranging DMM QM-1524

This Cat II DMM is suitable for voltages up to 600VAC and has 15mm-high digits for easy measurement.

- 10A current
- Diode Test
- 3.5 Digits
- Overload protection

$19.95

IP67 True RMS Autoranging Cat IV DMM

WITH WIRELESS USB QM-1571

A quality true RMS multimeter with a wireless USB computer interface, non-contact voltage indicator, relative zero and data hold. Double moulded housing is impact resistant and quite durable, and IP67 waterproof rating makes this DMM capable of even the harshest conditions. Wireless USB interface and included logging software allow for computer based live data logging whilst keeping your computer completely isolated and protected.

$109

Micro Sound Level Meter

QM-1591 **WAS $39.95**

With a range of 40 - 130dB, this little meter is ideal for environmental, safety and sound system testing. It has a fast response time for transient measurements and is A-weighted for the frequency range of human hearing.

ALSO AVAILABLE:

PRO SOUND LEVEL METER WITH CALIBRATOR QM-1592
WAS $349 NOW $314 SAVE $35

NOW $35.95

SAVE 10%

ESSENTIAL TOOLS

NOW $23.95

SAVE $6

Fujiya 110mm Precision Side Cutters

TH-2332 **WAS $29.95**

These cutters feature high quality tool steel construction with a sturdy box joint and are perfect for cutting super fine wire as well as general workshop use.

- 110mm long
- Blade hardness: Rockwell C Scale 57–61
- Soft grip handle

NOW $26

SAVE $6.95

ESD Safe Sidecutters

TH-1922 **WAS $32.95**

Specifically for ESD work. High quality Japanese designed, Italian manufactured cutters especially for static-sensitive applications. 135mm long.

2-in-1 Crimp & Test Tool

TH-1939 **WAS $69.95**

An integrated cable stripper and cutter, with detachable cable tester. it can quickly and easily test Ethernet twisted pair cables for wiring continuity, opens, shorts, and mis-wires. Includes PoE tester.

- Suits 10P, 8P, 6P, 4P
- Single and multi-wired cable wrimping

NOW $55.95

SAVE $14

20% OFF*

ALL PLIERS, CUTTERS & CRIMPING TOOLS

DON'T MISS OUT … FEBRUARY JAYCAR SALE VISIT US IN STORE OR ONLINE!

*Discounts OFF regular prices.
No further discount applies to already reduced lines. See page 8 for T&Cs.

DOUBLE POINTS FOR NERD PERKS CARD HOLDERS ON ALL UNINTERRUPTIBLE POWER SUPPLIES

Protect your valuable setup with our value-for-money Uninterruptible Power Supplies. Keep your systems running long enough to save critical data when the mains power fails.

	MP-5224	MP-5207	MP-5212
Features	Line interactive, economical model	Line interactive, smart LCD desktop model	On-line, smart LCD rack mountable (2U height)
Load Rating	600VA, 300W	1500VA, 900W	1000VA, 700W
Internal SLA Battery	12V/7AH x1	12V/9AH x2	12V/7AH x3
Output Waveform	Modified Sine Wave	Modified Sine Wave	Pure Sine Wave
Transfer Time	<10 ms	<10 ms	Instant
Power Outlets	6 x AUS (3 bypass, 3 mains)	2 x AUS mains	6 x IEC
Backup Time (Typical)	31 mins / 11 mins / 4.5 mins	94 mins / 49 mins / 31 mins	95 mins / 47 mins / 32 mins

DOUBLE POINTS

MP-5207 **$319**

DOUBLE POINTS

MP-5224 **$129**

MP-5212 **$449**

DOUBLE POINTS

RACK CABINET SPECIALS

19" Rack Mount Cabinets

Jaycar's 19" rack mount cabinets are ideal for IT or phone system installations, studios and PA systems, with a size and configuration to suit your application. These cabinets are solid steel powder coated to provide high strength and rigidity under load and are packed flat for convenient transport. Coupled with our wide range of accessories and options, these 19" rack mount hardware are value for money and offer you outstanding features found on more expensive units. Unbeatable value!

TECH TIP! SAVE TIME & MONEY
Jaycar also stocks highly practical and value-for-money network installation and troubleshooting testers. *See our website or ask us now.*

FROM **$59.95** SAVE UP TO $30

HB-5125

Equipment Cabinet
ALUMINIUM FRONT PANEL

1U HB-5120
WAS $60.95 NOW $59.95 SAVE $10

2U HB-5125
WAS $109 NOW $89 SAVE $20

3U HB-5130
WAS $129 NOW $99 SAVE $30

FROM **$139** SAVE UP TO $40

HB-5170

Fixed Frame
CLEAR TEMPERED GLASS DOOR

6U HB-5170
WAS $159 NOW $139 SAVE $20

12U HB-5174
WAS $229 NOW $189 SAVE $40

FROM **$199** SAVE UP TO $50

HB-5182

Swing Frame
CLEAR TEMPERED GLASS DOOR

6U HB-5180
WAS $229 NOW $199 SAVE $30

12U HB-5182
WAS $299 NOW $249 SAVE $50

15% OFF THESE 19" RACK MOUNT ACCESSORIES FOR NERD PERK CARD HOLDERS

HB-5432

NERD PERKS FROM **$19.95** SAVE 15%

Rack Cable Supports
Take the pain out of wiring and fault-finding rack cabinets. These high quality supports keep your cables organised and neat, and provides strain relief at the same time.

1U HB-5430 **WAS $24.95 NOW $19.95 SAVE $5**

2U HB-5432 **WAS $29.95 NOW $24.95 SAVE $5**

HB-5420

NERD PERKS FROM **$8.50** SAVE 15%

Blank Panels
Black powder coated panels for filling in unused space or configuring to your own requirements. Mount hardware included.

1U BLANK PANEL HB-5420
WAS $10.50 NOW $8.50 SAVE $2

2U BLANK PANEL HB-5422
WAS $12.95 NOW $10.95 SAVE $2

1U BLANK VENTED HB-5424
WAS $18.95 NOW $15.95 SAVE $3

2U BLANK VENTED HB-5426
WAS $27.95 NOW $22.95 SAVE $5

NERD PERKS SPECIAL **$24.95** SAVE 15%

Patch Lead Management Panel
HB-5434 **WAS $29.95**
1U size, keeps all your patch leads under control.

HB-5454

NERD PERKS FROM **$41.50** SAVE 15%

Rack Shelves
Ideal for equipment that you want to include in your 19" rack but doesn't have rack-mounting ears. Each shelf is punched with ample slots for ventilation and takes loads of up to 20kg.

1U FIXED SHELF HB-5452
WAS $49 NOW $41 SAVE $8

2U FIXED SHELF HB-5454
WAS $69 NOW $58 SAVE $11

1U SLIDING SHELF HB-5450
WAS $99.95 NOW $84.95 SAVE $15

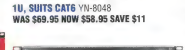
YN-8046

NERD PERKS FROM **$41.95** SAVE 15%

Cat 5/6 24-Port Patch Panels
Sleek attractive looking rack mount 24 port patch panel with a hard metal exterior. Numbered ports and a labelling area for each port.

1U, SUITS CAT5E YN-8046
WAS $49.95 NOW $41.95 SAVE $8

1U, SUITS CAT6 YN-8048
WAS $69.95 NOW $58.95 SAVE $11



NERD PERKS SPECIAL **$58.95** SAVE 15%

6-Way Power Distribution Unit
MS-4094 **WAS $69.95**
Power up to six 240VAC components in your rack setup. Surge/overload protected and fits any standard 19" rack. Includes 1.6m power lead.
- 1U rack space

HANDY TOOLS FOR NETWORK INSTALLERS

$22.95

Cat5 Adjustable Punch-Down Tool
TH-1740
Designed for seating wire into terminal blocks and has an adjustable internal impact mechanism. Supplied with 88 blade. 152mm long.

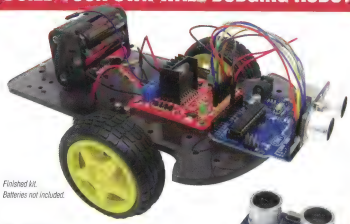
ALSO AVAILABLE:
110 REVERSIBLE KRONE BLADE TO SUIT TH-1743 **$17.95**

$14.95 SAVE $5

6P/8P Modular Crimp Tool
TH-1935 **WAS $19.95**
This tool will crimp 6P2C, 8P4C-RJ11, 6P6C-RJ12 and 8P-RJ45 plugs. Also cuts and strips the cable.

BUILD YOUR OWN WALL DODGING ROBOT WITH ARDUINO® FOR UNDER $100

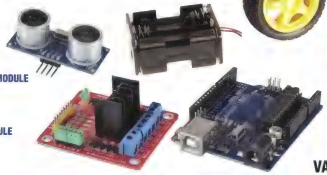
SEE STEP-BY-STEP INSTRUCTIONS ON WWW.JAYCAR.COM.AU/DIY-DODGING-ROBOT



Finished kit. Batteries not included.

BUNDLE DEAL INCLUDES:

DUINOTECH CLASSIC (UNO) XC-4410 **$29.95**
ARDUINO® COMPATIBLE STEPPER MOTOR CONTROLLER MODULE XC-4492 **$14.95**
6X AA BATTERY HOLDER PH-9206 **$1.75**
2WD MOTOR CHASSIS ROBOTICS KIT KR-3160 **$34.95**
ARDUINO® COMPATIBLE DUAL ULTRASONIC SENSOR MODULE XC-4442 **$7.95**
150MM PLUG TO SOCKET JUMPER LEADS – 40 PIECES WC-6028 **$3.95**



NERD PERKS CLUB
BUY ALL FOR $79.95
SAVE OVER $13

VALUED OVER $93

100% ARDUINO® COMPATIBLE

$7.95

Arduino® Compatible Mini Prototype Board Shield
XC-4480

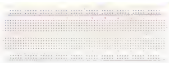
Drop this shield onto your Arduino® for prototyping small circuits. Solder-pads and a small breadboard is included which can be stuck to the top of the shield with the included tape.

- Fully compatible with Arduino®, Duinotech LEONARDO, Duinotech Classic

$9.95

Arduino® Compatible 2.4GHz Wireless Transceiver Module
XC-4508

This module allows communication on the license free ISM band. Despite its diminutive size, it supports on-air data rates of up to 2Mbps. No external components are required (other than your Duino').



FROM $4.95

Arduino® Compatible Breadboards

Breadboards for Arduino® and other DIY electronic projects. These have self-adhesive tape on the back for easy mounting or screws can be purchased for permanent mounting.

170 TIE POINTS PB-8817 **$4.95**
830 TIE POINTS with power distribution holes PB-8815 **$14.95**

$19.95

Solderless Breadboard WITH POWER SUPPLY PB-8819

Ideal for circuit board prototyping and Arduino® projects. The power module can be powered from either a 12V plug pack or from 5V using the micro USB socket with a switchable output between 3V and 5V DC.

- 1 x Solderless Breadboard with 830 Points
- 1 x Power Supply Module
- 64 mixed jumper wires of different lengths and colours

GO ONLINE OR IN-STORE TO SEE OUR EXTENSIVE RANGE!

$7.95

3-Axis Accelerometer Module FOR ARDUINO® XC-4478

This module allows you to measure acceleration, detect impacts and determine orientation. Perfect for robotics projects.

- 21(L) x 15(W) x 11(H)

$12.95

Arduino® Compatible Motor Servo Controller Module
XC-4472

It has 2 x 5V servo ports connected to the Arduino's high-resolution dedicated timer to ensure jitter-free operation. It is also capable of driving up to 4 bi-directional DC motors with individual 8-bit speed selection, or up to 2 stepper motors with single/two/ interleaved steppings.

$19.95

Arduino® Compatible Bluetooth® Module
XC-4510

Connected via the serial pins, and to your computer via Bluetooth®, this module creates a seamless serial-port link between you and your Duino' PLUS you can use it to communicate with your Bluetooth®-enabled smartphone.

- 28(W) x 13(L) x 8(H)mm

$19.95

Arduino® Compatible RF Transceiver Module
XC-4522

This module adds a versatile 433MHz radio to your Duinotech project allowing two-way wireless communication between Duinotechs. Controlled via SPI. Prewritten libraries available.

- Includes antenna.
- 32(W) x 19(L) x 19(H)mm (Excluding antenna)

SHIELDS AND MODULES

$4.95

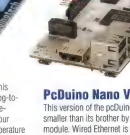
Arduino® Compatible Red Laser Diode Module
XC-4490
Need a red laser light for your latest project? Here it is! Everything you need to drive the laser diode is included on the board. Just connect it to 5VDC and you're good to go!
- 45(W) x 23(D) x 10(H)mm

$5.95

Arduino® Compatible PIR Motion Detector Module
XC-4444
A pyroelectric infrared PIR motion sensor is a handy addition to any Arduino® project. Wide operating range and delay times changeable. A must for any security application.
- 32(L) x 24(W) x 25(H)mm

$9.95

Arduino® Compatible Temperature and Humidity with this nifty module. Fully digital operated so no analog-to-digital calibration is required. Features resistive-type humidity measurement and is faster than our XC-4432, but less accurate with a smaller temperature range. Response wavelength 200-370nm
- 43(L) x 13(W) x 8(H)mm



$89.95

PcDuino Nano V3.0 XC-4352
This version of the pcDuino is substantially smaller than its brother by omitting the Wi-Fi module. Wired Ethernet is included at full 10PS speed.
- 95(L) x 55(W) x 17(D)mm

Limited stock, not available online.

$4.95

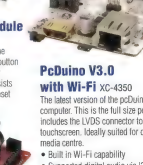
Arduino® Compatible 5V Relay Board
XC-4419
It provides the easiest way to use your DuinoTECH to switch real world devices. Includes back-EMF protection and LEDs so you can easily see the state of the outputs.
- 40(W) x 27(D) x 18(H)mm

$9.95

Arduino® Compatible 3 Axis Compass Magnetometer Module XC-4496
This module allows you to take accurate compass bearings, no matter how it is orientated. Easily interfaced via I2C.
- Includes 5V - 3V level shifter.
- 20(L) x 16(H) x 5(H)mm

$14.95

Arduino® Compatible 2 X 16 LCD Controller Module
XC-4454
Comes with a built-in 16 character by 2 line LCD display with backlight, this six push button keypad allows you to create a user friendly interface for your project. The keypad consists of up, down, left, right, select and also a reset button.
- 80(W) x 58(D) x 20(H)mm



DOUBLE POINTS

$119

PcDuino V3.0 with Wi-Fi XC-4350
The latest version of the pcDuino single-board-computer. This is the full size pcDuino board and includes the LVDS connector to connect an LCD touchscreen. Ideally suited for creating a wireless media centre.
- Built in Wi-Fi capability
- Supported digital audio via I2C.

$4.95

Arduino® Compatible X and Y Axis Joystick Module
XC-4422
This handy module gives you X & Y axis control for your Arduino project. The board is interfaced through 5 pin header and provides a small game-pad style joystick. There is also a tactile switch when you push the stick down.
- 47(L) x 25(W) x 32(H)mm

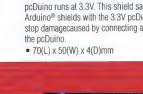
$9.95

Arduino® Compatible 5V Stepper Motor
XC-4458
A small, versatile motor and driver set that can be used with any Arduino® or compatible boards via jumper leads. Four-phase LED indicates the status of the stepper motor.
- 35(L) x 32(W) x 10(H)mm

Limited stock. Not available online.

$19.95

Arduino® Compatible Joystick Controller Module XC-4462
Similar to a PlayStation™ Controller, this shield has an analog joystick with a push down function button plus another four momentary push buttons. Add Bluetooth® module for a wireless controller.
- X,Y axis with push down button
- Voltage selectable 3.3V and 5VDC
- 87(L) x 54(W) x 18(H)mm



$29.95

DOUBLE POINTS

Voltage Converter Module FOR XC4350/52 PCDUINO XC-4362
While most Arduino® shields run at 5V, the pcDuino runs at 3.3V. This shield safely marries 5V Arduino® shields with the 3.3V pcDuino and will stop damagecaused by connecting a 5V shield to the pcDuino.
- 70(L) x 50(W) x 4(D)mm

GREAT SAVINGS ON THESE ARDUINO® PRODUCTS FOR NERD PERKS CLUB MEMBERS

NERD PERKS
SPECIAL $22.95
SAVE $5

ICSP Programmer FOR ARDUINO® XC-4237 RRP $27.95
Program new applications into a wide range of microcontrollers using this ICSP programmer with a USB interface. Compatible with Arduino® boards, ZZ-8726 ATmega328P MCU and fully supported by the Arduino® IDE, allowing you to install or update Arduino®-compatible boards and your own custom-made projects.

NERD PERKS
SPECIAL $24.95
SAVE $10

Arduino® Compatible Lock Shield Kit
XC-4215 RRP $34.95
Allows your Arduino® to control a door lock using an electric strike plate and one of a number of commonly available RFID modules. Based on a project in the book Practical Arduino®, which includes extensive documentation,storing gigabytes of web server content or data.

NERD PERKS
SPECIAL $49.95
SAVE $20

USBDroid – Interface with your Smartphone
XC-4222 RRP $69.95
Like an Arduino® Eleven but with microSD slot & USB port. Enables you to build your own Android™ (insert registered tm logo) peripherals to connect your phones to whatever you like. Includes built-in charger for Android™ device.
- Compatible with the Android™ Open Accessory Development Kit
- 58 x 53mm

Limited Stock

NERD PERKS
SPECIAL $69.95
SAVE $20

Large Dot Matrix LED Display Panel - Blue
XC-4251 RRP $89.95
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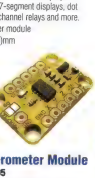

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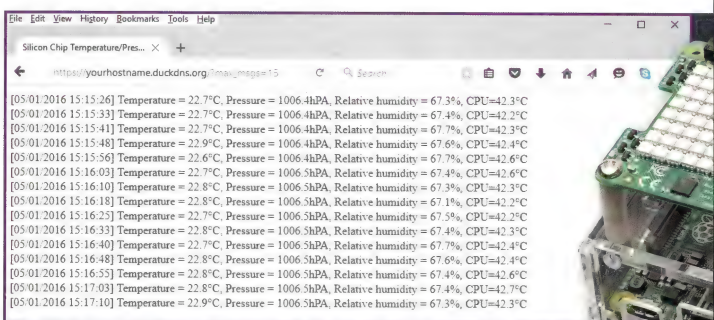


Fig.1: the temperature, pressure and humidity sensor readings as they appear on a web page. You can browse to these readings over your local network and via the internet.

RPi-based temperature, humidity & pressure sen

Getting our Raspberry Pi working with the Sense HAT sensor module was only the first step. This month, we show you how to install the system in a clear acrylic case and stream the sensor readings to a web-server so that you can easily access them over the internet (and on your local network) via a web browser.

LAST MONTH, we got our Raspberry Pi up and running, connected it to a local WiFi network, plugged in the Sense HAT module and ran some simple programs to measure temperature, pressure & humidity. We also showed you how to stream the RPi's desktop to another computer on the network, so that it can be run "headless" (ie, without a keyboard, monitor and mouse).

One problem we ran into was that the temperature readings were skewed by heat from the Raspberry Pi module. The Sense HAT module was plugged directly into the RPi's I/O connector, which meant that it sat directly above the RPi's ARM Cortex A7 CPU which typically runs with a core temperature of about 45°C (in 23°C ambient). We corrected for this by introducing a compensation factor into our Python temperature measuring software but this was only valid over a fairly narrow temperature range.

The obvious answer was to separate the two modules by plugging the Sense HAT into the RPi via stackable headers. In addition, by mounting the RPi in a case, the underside of the Sense HAT module would be partially shielded from the heat generated by the RPi's ARM processor and any other on-board parts, such as the GPU.

So that's what we've done. We chose to fit the RPi module in a clear acrylic case from Core Electronics (Cat. 018-RASP-PI+CASE1). It costs just $8.50 (plus p&p) and comes as a flat pack; you just clip it together to assemble it.

This case has a cut-out slot along one edge of the lid immediately above the RPi's I/O header, so that external modules can be plugged in via stackable headers. It also

Pt.2: By Greg Swain

Above: the Raspberry Pi module is housed in a clear acrylic case, while the Sense HAT module rests above the case lid. It plugs into the RPi via two stackable headers.

Additional Parts Required

1 acrylic case, Core Electronics SKU: 018-RASP-PI+CASE1 (for Raspberry Pi B+)*
1 Stackable female header with spacers, Core Electronics SKU: POLOLU-2749*
1 stackable header, Core Electronics SKU: POLOLU-2748*
2 M3 x 12mm tapped Nylon spacers
2 M3 x 8mm tapped Nylon spacers
2 M3 x 15mm machine screws

* www.core-electronics.com.au for case and header parts

has a slot in the lid above the camera interface connector and another slot at one end above the display interface connector.

Before clipping the case together, it's necessary to cover the slot for the camera interface connector (the one adjacent to the HDMI connector) to prevent warm air from the RPi reaching the underside of the Sense HAT module. We used a 25 x 20mm piece a clear acrylic with 3mm-diameter holes drilled on either side. A couple of matching holes were then drilled in the lid and the cover secured in place using M3 x 10mm machine screws, nuts and washers.

The case we obtained had no hole in the lid for a fan. However, the case shown on Core Electronic's website now includes a hole for a 40mm fan and if your case has this cut-out, then this will have to be covered as well. In fact, it would be best to cut a single piece of acrylic sheet to cover both the fan cut-out and the slot for the camera interface.

One minor problem we found with the case was that the hole for the micro-USB power connector wasn't quite large enough. In practice, it blocked the insulated body at the end of the connector, preventing it from being pushed home far enough into the RPi's power socket to stop it falling out. That problem was solved by carefully enlarging the hole using a small file set.

There's a useful trick when doing this. First, trace the side piece, including its cut-outs, onto a piece of paper, then carefully measure your micro-USB power connector and enlarge the traced outline for this connector accordingly. The side piece can then be carefully filed until the cut-out matches the paper template.

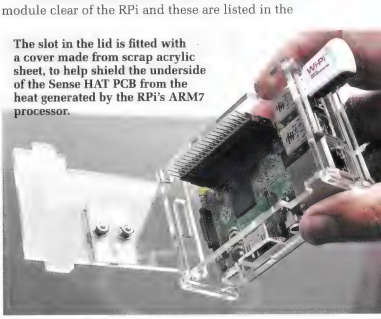
Depending on your HDMI cable, you may also have to do the same for its socket cut-out.

Once you've done this work, the case can be assembled but take your time to figure out how it goes together. In particular, the lid must be fitted before the second side piece is installed (see core-electronics.com.au/ultimate-case-box-enclosure-combo-for-raspberry-pi-b.html). The end piece with the cut-outs for the ethernet and USB sockets can be fitted last, just after the RPi module is slid into position. Make sure that this end piece is attached the right way around, otherwise you will not be able to access all the USB sockets.

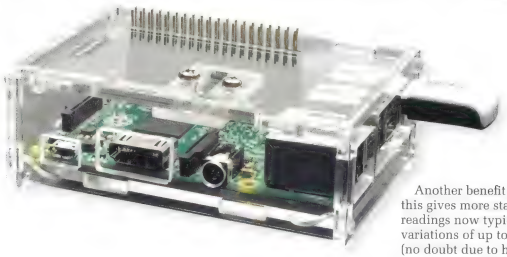
If you do make a mistake, it's easy to pull the case apart – just lift up the clips at the bottom on either side of an end piece and slip the piece off. The other end piece can then be removed in the same manner.

Stackable headers

Two stackable headers are used to lift the Sense HAT module clear of the RPi and these are listed in the



The slot in the lid is fitted with a cover made from scrap acrylic sheet, to help shield the underside of the Sense HAT PCB from the heat generated by the RPi's ARM7 processor.



This view shows the completed RPi assembly before the Sense HAT module is fitted. The holes in the side of the case for the power and HDMI sockets were enlarged using a file set. Take care with the case assembly – see text.

accompanying parts list. They can be fitted to the RPi in either order, although it's probably best to have the tall unit on top. The standard unit has longer exposed pins when everything is plugged in and these are best contained inside the case.

Before connecting the Sense HAT, it's necessary to attach Nylon spacers to the two mounting holes on the side opposite the header. Two spacers are required in each position, one M3 x 12mm and the other M3 x 9mm, and these are attached to the Sense HAT using M3 x 15mm machine screws.

There's really no need to attach the spacers to the case lid; they can simply rest on the lid when the Sense HAT is plugged into the header.

Alternatively, if you're fussy, you can drill a couple of holes in the lid and attach the 12mm spacers using M3 x 9mm machine screws. The M3 x 9mm spacers can then be drilled out (to remove the thread) and the assembly then secured at each corner using M3 x 15mm machine screws.

Better accuracy

By enclosing the RPi module in the case, its heat no longer has such a large affect on the temperature readings. There is still some degree of warming around the unit though, and the Sense HAT unit itself also slightly contributes to this, but the result is that the readings are more accurate than before.

At switch on from cold (23°C ambient), our unit's temperature readings were about 0.3°C high without compensation but this increased to about 4.3°C after the unit had been on some time and had reached a stable operating temperature. They were previously around 10°C or more too high, so that's quite an improvement.

This means that a much lower compensation value is now required to correct the temperature reading. Whereas previously a compensation value of around 0.8 was required, a value somewhere around 0.35 will now give reasonably accurate readings for temperatures in the range of ~20-30°C. The compensation factor not only corrects for local warming around the unit but also helps correct for any inaccuracy in the sensor itself.

You can insert this new compensation value into the Environment2.py program listed in Pt.1 by changing:

```
ta = round((t-(ct-t)*0.8),1) to
ta = round((t-(ct-t)*0.3),1)
```

Another benefit of enclosing the RPi in a case is that this gives more stable temperature readings. Successive readings now typically vary by just 0.1°C as opposed to variations of up to 0.4°C with the previous arrangement (no doubt due to hot air rising from the RPi and circulating under the Sense HAT module).

Apache web server

In order to access the Sense HAT's readings over the internet, we need to install the Apache2 Web Server and the mod_python module. Mod_python is simply a module that embeds the Python interpreter within the Apache2 server and allows the two to work together.

First, make sure that the system is completely up-to-date:

```
sudo apt-get update
sudo apt-get upgrade
sudo reboot
```

You can now install the web server and Python module and get it running. That's done by opening a Terminal window and entering the following:

Step 1

```
sudo apt-get install apache2
sudo apt-get install libapache2-mod-python
```

Step 2

sudo nano /etc/apache2/sites-available/000-default.conf and add the following lines under the DocumentRoot line (be sure to insert tabs as shown):

```
AddHandler mod_python .py
  <Directory /var/www/html>
     DirectoryIndex index.py
     PythonHandler mod_python.publisher
     PythonDebug on
  </Directory>
```

Once these lines have been added, hit Ctrl-o to save the file and Ctrl-x to exit Nano. Note: if you don't feel comfortable using the Nano text editor, then run **sudo leafpad** from the Terminal, then open and edit the file using the Leafpad GUI text editor.

Step 3

Now add the same lines to ***/etc/apache2/sites-available/default-ssl.conf*** for SSL (Secure Socket Layer) support. Connecting using **https://<address>** instead of **http://<address>** will give secure communications between your browser and the Apache2 server.

Step 4

We now need to give Apache2 access to the I²C sen-

sors on the Sense HAT. To do this, enter the command **sudo nano /etc/group** and change the line

```
i2c:x:998:pi  to  i2c:x:998:pi,www-data
```

Then change

```
video:x:44:pi  to  video:x:44:pi,www-data
```

Step 5

Next, create a hidden configuration folder for the sensor data:

sudo mkdir /var/www/.config

sudo chown www-data /var/www/.config

Step 6

We now enable SSL support by running:

sudo a2ensite default-ssl

sudo a2enmod ssl

Note that this will use a self-signed certificate which will require you to add an exception to your browser when you first visit the site.

Step7

Restart the Apache2 service for the changes to take effect:

sudo service apache2 restart

If it fails to restart and gives an error indicating a problem with the Python module, check that the entries you added in ***sites-available/000-default.conf*** and ***sites-available/default-ssl.conf*** are correct. If so, then run:

sudo a2enmod python

and then run the command to restart the Apache2 service again. Note: the Python module should be enabled when it is installed but if not, the above command will enable it.

Step 8

Check that the Apache2 web server is working. To do that, simply browse to the RPi's IP address (ie, **http://<ipaddress>**), either from another computer on the network or on the RPi itself. If you see the default web page as shown in Fig.1, that means it's working.

Step 9

The next step is to get Apache2 working with the Python module to display the Sense HAT readings. That's done using a program called ***index.py***. You have to download this file (embedded in ***index.py.zip***) from the SILICON CHIP website, unzip it and move it into the RPi's ***/var/www/html*** folder.

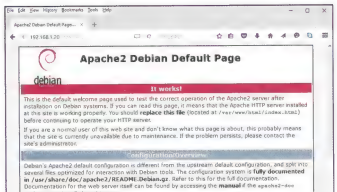


Fig.1: the default page for the Apache2 web-server. If you see this, then Apache2 is working correctly.

The easiest way to do this is to first download the file using the RPi's web browser. Browse to **www.siliconchip.com.au**, then click Shop, select Software from the drop-list and left-click the ***index.py.zip*** file. The file will immediately download into the ***/pi/Downloads*** folder. Navigate to this folder, then right click the zip file to extract its content.

Index.py can now be moved to the required folder as follows:

sudo mv /pi/Downloads/index.py /var/www/html

That's it! – it should now work. Using a computer on the local network (or the RPi itself), browse to **http://<ipaddress>** (or optionally use **https://<ipaddress>** assuming SSL support is enabled, as described above). Temperature, pressure & humidity readings should immediately begin appearing on the web page, as shown on page 54.

By default, the program has a compensation factor of 0.3, updates the reading every five seconds (5s) and displays a maximum of 10 messages at any one time (the message scroll up the screen). However, you can easily

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Keeping The Baddies Out

Because it sits behind your router's hardware firewall (and the software firewall, if enabled), your RPi should be reasonably secure. However, opening port 443 on the router (to enable internet access to the web-server) does provide a potential security problem. That's why it's important to choose a strong password for the Apache2 authentication log-in.

Fail2Ban

Despite this, the web-server's log-in prompt will soon attract brute force attempts to gain access by people running password dictionaries. There's an easy way to defeat such attacks, though: limit the number of log-in attempts by using an intrusion detection software utility called "Fail2Ban".

Fail2Ban works by monitoring the logs generated by various services (such as Apache2). If there are too many failed log-in attempts, it then temporarily (or even permanently) bans the offending IP from making further attempts. For example, it can be configured to allow three log-in attempts and, if all are unsuccessful, ban the offending IP for 20 minutes, depending on the settings in the configuration file.

In practice, Fail2Ban sets up a few simple iptable firewall rules (iptables is the utility used to configure Linux firewalls). It then automatically alters these rules after the preset number of failed log-in attempts. By default, it monitors SSH (port 22) only but it's just a matter of altering its configuration file to include other protocols such as HTTP (port 80) and HTTPS (port 443), as used by Apache2.

An excellent guide on installing and configuring Fail2Ban can be found at www.digitalocean.com/community/tutorials/how-to-protect-an-apache-server-with-fail2ban-on-ubuntu-14-04 It's just a matter of following this guide to configure it so that, as well as SSH, it also monitors the RPi's Apache2 server.

Important points

Note that you have to copy the default configuration file to ***/etc/fail2ban/jail.local***. You then edit this new file (it overrides the original configuration file) to set the "bantime", the maximum number of tries ("maxretry") and the "findtime" (the time period over which the retries are counted). The default bantime is 600 seconds but you can increase this (eg, to 1800 seconds) or enter a negative number to ban the offending IP forever.

Note that it's particularly important to scroll down to the [apache] jail and change to line **enabled = false** to **enabled = true**. Fail2Ban will then cover both http and https.

Installing a firewall

Unless you've opened up myriad ports on your router, a separate firewall on the RPi (apart from the Fail2Ban rules) isn't really necessary. However, if you're a "belts'n'braces" type or you just want to experiment, consider installing Uncomplicated Firewall (UFW) which is an easy-to-use iptables configuration utility.

The following website has the basics on UFW's installation and usage: www.digitalocean.com/community/tutorials/how-to-set-up-a-firewall-with-ufw-on-ubuntu-14-04

Of course, all bets are off if you decide to add the RPi to your router's DMZ (demilitarised zone). Placing it in the DMZ means that it cannot contact other devices on your internal LAN in the event that it's compromised (it's added to the DMZ by logging into your router and going to the DMZ set-up page).

The downside is that all ports on the router will then be forwarded to the RPi, so it's wide open. As a result, a firewall is then an absolute must.

In practice, you would set up the firewall to initially block all incoming ports. You then create rules to open port 443 (for https) and port 22 (or whatever you change it to; see the panel "Connecting Via SSH & VNC") if you want connect via SSH (secure shell).

alter these parameters, either in the ***index.py*** program itself or by adding switches to the website address, eg:

http://<ipaddress>/?max_msgs=5
http://<ipaddress>/?interval=60
http://<ipaddress>/?compensate=0.4

You can also string these switches together, eg, **https://<ipaddress>/?compensate=0.4&max_msgs=5&interval=60** applies a compensation factor of 0.4, shows a maximum of five messages on the screen and updates the readings every 60 seconds.

Step 10

If you plan on making the RPi's website accessible via the internet, then it's a good idea to require password access. To do this, run:

```
sudo apt-get install apache2-utils
sudo a2enmod authn_dbm
sudo htdbm -TSDBM -c /etc/apache2/dbmpasswd <username>
<enter password>
sudo chown www-data /etc/apache2/dbmpasswd.pag
```

Be sure to choose a strong password. It should be a mixture of upper case and lower case letters, numbers and alphanumeric symbols.

That done, go to the two Apache2 configuration files (ie, ***000-default.conf*** and ***default-ssl.conf***) and add the following lines under the lines you added in Steps 2 & 3:

```
AuthType basic
AuthName "private area"
AuthBasicProvider dbm
AuthDBMType SDBM
AuthDBMUserFile /etc/apache2/dbmpasswd
Require valid-user
```

Then do: **sudo service apache2 restart**

If you are using passwords, you should also use SSL (ie, set up as per above) and use ***https://*** to access the site, otherwise your password could be intercepted.

Now, whenever you attempt to browse to the RPi's web server, you will initially be greeted by a dialog box asking you to enter your user-name and password.

Accessing it via the internet

In order to access the RPi's web server over the internet, you have to do the following:

(1) assign a fixed IP address to the RPi (by default, it has a dynamic IP that's assigned by the router's DHCP server);

(2) set up a port forward on your router; and (3) determine your public IP address.

The easiest way to fix the RPi's IP address to to assign an IP to its MAC address (or "Hwaddr") in the router. A MAC address is simply a unique code consisting of 12 hexadecimal characters that's assigned to every network device, such as a WiFi dongle. To discover the MAC address of your RPi's Wi-Pi dongle, run **ifconfig** in a Terminal window; the address consists of the 12 characters immediately following "Hwaddr" under wlan0.

That done, log into your router and look for the DHCP set-up page, LAN IP page or similar. You can then enter the Wi-Pi's MAC address and assign it an IP. The router's DHCP server will then always hand out that IP to the RPi (ie, it will remain fixed). Fig.2 shows the set-up on a Netgear cable modem/router.

The next step is to set up port forwarding. Basically, a firewall is built into the modem/router. In order to make a connection to the RPi's web server, you have to open up (or forward) the relevant port in this firewall so that data can pass through.

By default, Apache2 uses port 443 for https (port 80 for http) and this must be forwarded to the RPi's fixed IP address. To do this, navigate to the router's port forwarding set-up page, enter the relevant port number and IP details and click "Add" (or similar).

Fig.3 shows the set-up for a Netgear cable modem/router. As can be seen, port 443 has been forwarded for https, the RPi's fixed IP address is 192.168.1.20 (yours may be different) and TCP is used for the protocol. Other routers will have similar menus.

Similarly, port 9630 has been forward for SSH (secure shell) access (see panel: Connecting Via SSH & VNC).

Once you've configured the router, save the set-up and logout. You may also have to restart the router for the settings to take effect.

The last step is to obtain your public IP address. That's easy – browse to **www.whatismyip.com/**and your public IP will be displayed.

If you now enter **https://<yourpublicIPaddress>** in a web browser on your PC, the login diaglog for your RPi should immediately appear. Enter your user-name and password (ie, for the Apache2 server), and the Sense HAT readings should immediately begin scrolling down the page.

Note, however, that some home routers don't support "loopback", whereby you can use your WAN IP to connect to a computer on your local network. If that's the case, try logging in using a computer that's outside your LAN or switch off the WiFi on your smartphone and try connecting via its browser.

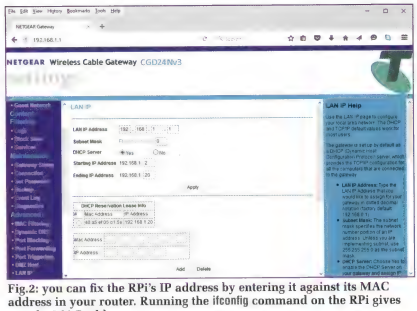


Fig.2: you can fix the RPi's IP address by entering it against its MAC address in your router. Running the ifconfig command on the RPi gives you the MAC address.

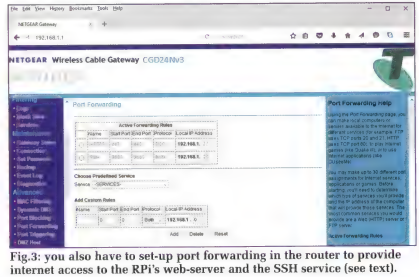


Fig.3: you also have to set-up port forwarding in the router to provide internet access to the RPi's web-server and the SSH service (see text).

Dynamic DNS (DDNS)

One weakness of the above scheme is that, unless you've been issued with a static address by your ISP, your WAN (wide area network) IP address is likely to change over time. And if it does change, you will not be able to log onto the RPi over the internet until you check the new address from your local network.

In many cases, that's not likely to be much of an inconvenience. Provided you leave your modem/router on, your WAN (or public) IP may stay the same for weeks, months or even years. However, inevitably, it will change. The modem/router may pick up a new IP when it's restarted after being switched off for some time or when it comes back online after a blackout, for example.

The way around this is to sign up to a DDNS service. DDNS stands for "Dynamic Domain Name Server" and it allows you to log onto your home network without knowing its WAN IP. Instead, the DDNS automatically keeps track of your WAN IP (even when it changes) and allows you to connect using a domain name. A domain name also has the advantage of being much easier to remember than a WAN IP.

The way in which DDNS works is straightforward;

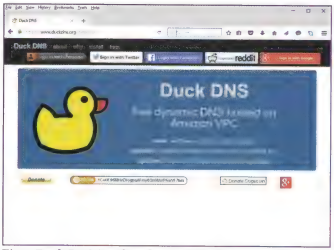


Fig.4: Duck DNS is a free dynamic DNS provider. You simply sign in using your Google (or other) account and choose a hostname. You can then access the RPi's server over the internet using https://hostname.duckdns.org

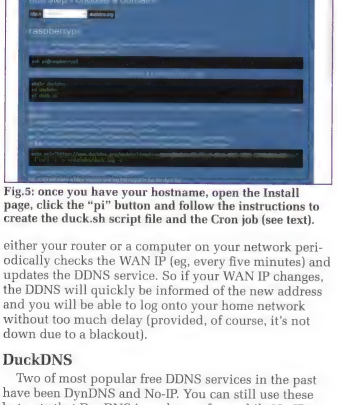


Fig.5: once you have your hostname, open the Install page, click the "pi" button and follow the instructions to create the duck.sh script file and the Cron job (see text).

either your router or a computer on your network periodically checks the WAN IP (eg, every five minutes) and updates the DDNS service. So if your WAN IP changes, the DDNS will quickly be informed of the new address and you will be able to log onto your home network without too much delay (provided, of course, it's not down due to a blackout).

DuckDNS

Two of most popular free DDNS services in the past have been DynDNS and No-IP. You can still use these but note that DynDNS is no longer free, while No-IP nags you to confirm your hostname every 30 days (unless you sign up for a paid version).

These two DDNS services are supported by many routers, although many older Netgear routers only support DynDNS. If your router supports your preferred

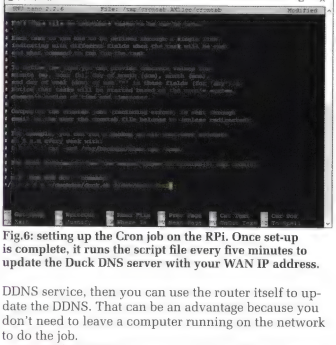


Fig.6: setting up the Cron job on the RPi. Once set-up is complete, it runs the script file every five minutes to update the Duck DNS server with your WAN IP address.

DDNS service, then you can use the router itself to update the DDNS. That can be an advantage because you don't need to leave a computer running on the network to do the job.

A great free DDNS alternative is Duck DNS at **www.duckdns.org** In most cases, it won't be supported by your router but there's an easy answer to that problem – use the RPi itself to run a script to update the Duck DNS server.

To set up Duck DNS, sign in on their home page using your Google, Twitter, Facebook (or other) account (Fig.4), then give Duck DNS permission to discover your email address and WAN IP. You then enter your desired hostname into a dialog box and if it hasn't already been taken, it's yours and you will also be assigned a "token".

You should now be able to connect to your RPi using the domain name, ie ***https://yourhostname.duckdns.org***

Next, you need to configure the Raspberry Pi so that it periodically contacts the Duck DNS server to update the WAN IP. That's done using what's known as a "Cron job" (Cron is name given to a software-based job scheduler that's used in Linux). Duck DNS makes this easy:
(1) click the "install" menu at the top of their webpage;
(2) click the "pi" button under Operating Systems;
(3) select your given hostname under "first step – choose a domain"; and
(4) follow the instructions to create the necessary script file and the Cron job (see Fig.5 & Fig.6).

Note that if you are working directly on the RPi, there's no need to run the ssh command line – just open a Terminal window and kick off with **mkdir duckdns** (do not use sudo). This will create a **/duckdns** folder under your **/pi** user folder.

You may be more comfortable using Nano or even the Leafpad GUI text editor rather than the vi text editor to create the duck.sh file (eg, **nano duck.sh** instead of **vi duck.sh**). In addition, note that you don't have to run the last command listed (**sudo service cron start**) for the Raspbian operating system.

Provided it returned "OK" when you ran **cat duck.log** as instructed, your RPi will now update the DuckDNS server with your WAN IP every five minutes. What's

Connecting Via SSH & VNC

If you want to control your RPi over the internet, it's best to log-in via SSH (secure shell). This gives a secure command line interface, provided you've chosen a secure user password for your RPi.

SSH is enabled by default when Raspbian is installed but can be disabled (or enabled again) using **raspi-config**.

You can stick with SSH's port 22 default if you like but we recommend that you change it to something else. If port 22 is forwarded on the router, it will quickly be found and bombarded by hackers making repeated attempts to SSH their way in using brute-force methods. While Fail2Ban will quickly deal with this, changing the port number will drastically reduce the number of unauthorised log-in attempts in the first place, simply because the default SSH port is not being used.

It's best to choose a high port number, eg, 9321, 9630 or 10101, or similar. That's done by editing the ***sshd_config*** configuration file:

sudo nano /etc/ssh/sshd_config

Change the Port 22 line to the new port number (eg, Port 9321). Then do:

sudo service ssh restart

You can then log-in to your router and forward the port so provide SSH access into the RPi over the internet.

Mac and Linux machines both natively support SSH but a Windows PC will require the installation of an SSH client such as PuTTY. Download the putty.exe file from www.putty.org/, then right-click the file and drag a shortcut onto the desktop.

You're now set to SSH into the RPi: launch PuTTY, enter either your host name (eg, ***yourhostname.duckdns.org***) or your WAN IP address, then enter the port number and click the Open button. This will bring up a terminal window and it's then just a matter of logging in with your RPi's user name and password (see Fig.7).

From there, you can control the RPi by entering commands, just as if you were directly using the RPi's terminal. Entering exit or Ctrl-D closes the connection and the terminal window.

Using VNC Over the Internet

Directly accessing the RPi over the internet using VNC can be a security risk since all traffic apart from the password (which is limited to just eight characters) is unencrypted. You would also have to open up port 5901 on the router and again that's bound to attract brute-force authentication attempts.

The way around this is to tunnel the VNC connection via an SSH log-in. SSH ensures that all data is encrypted and, as a bonus, you don't have to open up additional ports on the router.

Setting it up and connecting is a breeze:

(1) Launch PuTTY, enter in your host name (or WAN IP address) and the port number (Fig.7);

(2) Enter a session name in Saved Sessions;

(3) In the lefthand panel, expand the entries under SSH and select Tunnels.

(4) In the resulting dialog, enter 5901 in **Source port** and localhost:5901 in **Destination**, then click Add. These entries will then be loaded into **Forwarded ports** (Fig.8).

(5) In the left-hand pane, click Session, then click the Save button.

That's it! – double-click the Saved Session in PuTTY (or select it and click Load, Open) and log in. You can now securely connect to the RPi's VNC server via the SSH tunnel by launching TightVNC and entering **localhost:1** in the VNC Server field (Fig.9).

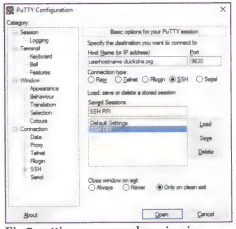


Fig.7: setting up a saved session in PuTTY, the Windows SSH client. Note that the RPi's SSH port number was changed from 22 (the default) to 9630.

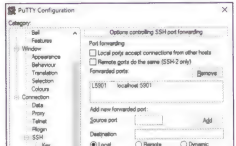


Fig.8: here's how to set up an SSH tunnel in PuTTY for a VNC connection.

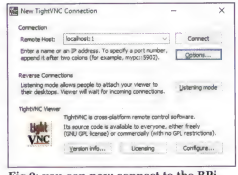


Fig.9: you can now connect to the RPi via SSH, then connect via TightVNC by entering localhost:1 for the Remote Host.

more, you will now be able to log into your RPi over the internet using your domain name rather than a cumbersome and easy-to-forget WAN IP address.

How secure is it?

So how secure is the whole set-up? The answer is about as secure as the strength of your password unless you lock it down. Fortunately, there are a few simple steps you can take to secure your RPi down, so that you don't get hacked. Take a look at the accompanying panels: "Keeping The Baddies Out" and "Connecting Via SSH & VNC".

Browsing Confined To A LAN

If you're going to be browsing to your RPi's web-server over your local network (LAN) only, then there's no need for password authentication. In that case, you can leave out all of Step 10 and simply browse to the server using **http://<ipaddress>**

Confining access to the local network also means that there's no need to open up the relevant port on your router. In fact, you should leave that port closed if you don't require external access. SC

Crowd funding your electronics product – Kickstarter and 'The Joey'.

By Steve OBrien and David Meiklejohn

KICKSTARTER

Have you got a great idea for an electronic product? You've designed it, it works – and now you'd like to build and sell some. How do you cover the cost of building the first batch? And how do you find your first customers? Kickstarter may be the answer for you ...

Kickstarter is a crowd-funding web site, based in New York but it is a global web business. You sign up and describe your project idea and your project plan. If it is a technology product then you must have a prototype to demonstrate.

Once the project meets Kickstarter's requirements it can "go live" and the campaign runs for up to 60 days, although one month is recommended.

People can choose to back the project by pledging to buy your product and if the funding target is reached then you can proceed to deliver your project.

It's all about minimising risk on both sides – if your project doesn't reach its funding goal, everyone walks away without paying a cent and you haven't sunk money into building a product which may not be viable.

There have been some very successful Kickstarter projects; two outstanding campaigns we'll mention here are the Pebble and the Flow Hive.

Pebble Smartwatch

The Pebble is a smart watch, designed to provide an affordable alternative to the well known smart watch suppliers. Pebble raised over US$10 million inside one month in early 2012 – that was the biggest dollar value Kickstarter project at that time. Using this capital to fund further development and production, Pebble watches started delivery and they have now manufactured more than one million units.

In 2015 Pebble announced a second Kickstarter campaign for a new version watch, the 'Pebble Time'. It raised US$500,000 in the first 17 minutes! It then hit US$1 million in 49 minutes, US$10 million after 48 hours, and more than US$20.3 million after 1 month (the end of the campaign) with over 78,000 backers.

So they financed their product and got their first 78,000 customers at the

Two highly successful Kickstarter campaign products from completely different areas. On the left is the Pebble Smartwatch which achieved $US20.3 million in funding. At right is the Australian Flow Hive, which hoped to raise $US70,000 but achieved $US12 million Kickstarter funding from 24,000 backers in 130 countries.

same time!

The Flow Hive

Good old Aussie ingenuity is still alive and well – at least that is what 24,000 Flow Hive backers believe. The Flow Hive introduced a new way to extract honey from a bee hive.

Traditionally, honeycombs need to be lifted out of the hive and the wax is scraped away so the honey can drip into a collecting bucket. This disturbs the bees – and smoke is commonly used to subdue them.

In a different approach to the problem, the flow hive includes new honeycomb frames that separate when you turn a handle from outside.

When the honeycomb cells are separated, the honey can trickle down and exit through a pipe at the bottom. You don't have to open the hive or remove the honeycomb arrays and the bees are much happier about it as well!

It was put up on Kickstarter in early 2015 in the hope of raising $70,000. The promoting video for Flow Hive went viral and they had reached their $70,000 target within a few minutes and hit US$2 million within the first 24 hours! By the end of the campaign they had over US$12 million and 24,000 backers in 130 countries across the world!

Now they have to build and ship approximately 24,000 hives – but having too many orders is what's called a 'high class problem'. The ABC covered the Flow Hive in their "Australian Story" series in 2015.

Other crowd funding websites

While Kickstarter is the biggest crowd funder, there's nothing new about crowd funding. In 1885 a newspaper campaign raised money to build the base for the Statue of Liberty (the statue itself was a gift from the French government to the people of the United States). Joseph Pulitzer, as in the literature prize, instigated the campaign.

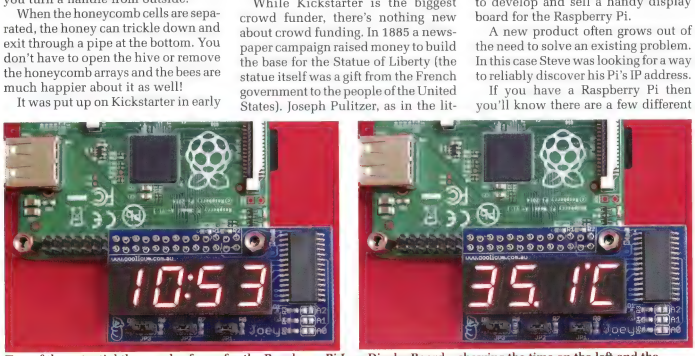
Of course, crowd funding is not always for electronic products, in fact there are hundreds of crowd funding sites of many different types and a huge range of projects get proposed and funded, from films to books, gadgets, video games, music pop groups. Crowd funding sites also exist for investment, real estate and philanthropy. (Kickstarter itself does not cater for charities or similar fundraising).

The Joey – a Raspberry Pi display board

The Joey is a collaboration between the authors of this article, who agreed to develop and sell a handy display board for the Raspberry Pi.

A new product often grows out of the need to solve an existing problem. In this case Steve was looking for a way to reliably discover his Pi's IP address.

If you have a Raspberry Pi then you'll know there are a few different



Two of the potential thousands of uses for the Raspberry Pi Joey DisplayBoard – showing the time on the left and the temperature on the right. The beauty of the Joey is that it doesn't prevent other boards being stacked nor use I/Os.

The Kickstarter page displaying the Joey and a brief description of what it does. Along with this page, a promotional video was produced. Notice the bottom line: The Joeys have all shipped!

ways to connect to it. Direct connection involves either a keyboard, mouse and screen, or a serial port and terminal emulator into the console.

An alternative, and often more convenient, way to connect to your Pi is over a computer network, either LAN or WiFi. But to do this you first need to know the IP address of your Raspberry Pi.

For a fixed IP address, no problem. But a lot of the time IP addresses are allocated dynamically and it is not always easy to find out what IP address your Pi has been given, especially if you've taken it to a meet-up.

Ideally, the Raspberry Pi would tell you the address it has been assigned. One approach is for the Pi to upload the new IP address to a website. Open that page with a browser, identify your Pi and copy the address listed.

Another method is to run a script so that the Pi sends an email with the IP address each boot up.

LOOKING FOR A PCB?
PCBs for most recent (>2010) SILICON CHIP projects are available from the SILICON CHIP PartShop – see the PartShop pages in this issue or log onto
siliconchip.com.au/shop
You'll also find some of the hard-to-get components to build your SILICON CHIP project, back issues, software, panels, binders, books, DVDs and much more!

Both approaches work fine but they need a working internet connection to the outside world.

If you want to be independent of the internet or if your connection is down, you need another solution. So Steve came up with the idea of a small display which attaches directly to the Raspberry Pi's I/O connector.

When the Raspberry Pi boots up it displays the IP address numbers in sequence and you can type these in to get connected.

David had faced a similar problem, so saw the appeal of a small, unobtrusive numeric display, especially if it could be used alongside other Raspberry Pi add-ons.

It could be used to display sensor readings, a count, elapsed time, etc. Although plenty of Raspberry Pi display boards are available, it can be hard to use them with other expansion boards – a lot of boards don't stack and some use conflicting I/O pins.

And you don't need fancy graphics when you only need to display a simple numeric value.

So they decided that the Joey would connect via I^2C, to avoid the potential for conflict with the General Purpose I/O (GPIO) pins used by other add-ons and also made a 0.8mm thick PCB that sits off to the side, allowing other Raspberry Pi expansion boards to plug over the top.

Joey uses a generic 4-digit display, so users can write to and display any numbers or letters that 7-segment displays support – handy for a wide range of projects.

They had a great product idea, filling a real market need. But would it sell?

It sounded like a perfect fit for a Kickstarter project!

The Kickstarter Campaign

Before you start a Kickstarter campaign you must set a target amount of money that needs to be achieved. Each campaign typically runs for one month and is "All or Nothing". If the target isn't reached then the project is cancelled – and you can't change the target mid-campaign.

Kickstarter take a 5% commission of the project total if successful and another 3% (or so) in funds collection fees.

They had to decide how many Joeys they'd need to build to get the unit price "low enough".

After researching manufacturing costs and competitors (how much do other displays cost?), they found that they would need to build at least 500 boards.

So they needed to set the funding goal high enough to cover the cost of building 500 Joeys, plus 8% for the Kickstarter fees.

The next decision was how much to charge for each Joey. Backers actually 'pledge' to buy 'rewards' (the Joey display boards) for a minimum amount which the Kickstarter campaigners specify.

It's common to include a limited number of "early bird" rewards at a lower unit cost, to get the ball rolling and build some buzz quickly.

They decided to price the rewards so that, if they sold around 250 Joeys, they would just about cover production and distribution costs. They would be left with some extra boards that could be sold later.

Promotional Video

The best way to explain your project is to make a video for the project page. In fact Kickstarter rules insist that you have a prototype built before you can go live.

Steve lives near a Sydney flight path and doesn't always notice the plane noise, but on the promotion video they made the planes were extremely obvious, so most of the audio had to be re-recorded later at another location.

So don't shoot your Kickstarter video on a Saturday morning in Syd-

ney's inner west!

Volume Production – China or Australia?

When planning to make about 500 Joey boards, the question naturally arises – manufacture in Australia or China?

The Joey boards could be built in Australia for only a few dollars more than China pricing, so local manufacturing costs are not the main expense in this case.

But it turned out the international freight costs to send the Joeys to backers all around the world out of Australia were the killers.

The cheapest package delivery from Australia costs over $10 (around the same cost as the Joey sells for!) and with tracking it is even more expensive.

But from China small packages can be sent worldwide for $3 or less! Additionally the Joeys are stored at a logistics centre in China at low cost and held until dispatch is requested.

So Australian manufacturing loses out because the total cost to global customers is not competitive.

A downside of manufacturing in China is that the critical step of building and testing prototypes takes longer than it would working with an Australian manufacturer.

In fact, they had to go through a couple of prototype versions before the final changes were sorted out.

Marketing.

How do you find potential customers and tell them about your Kickstarter project?

In Steve and David's case, they sent emails to all business, professional contacts & friends to spread the word. They then sent tweets since Gooligum Electronics (David's web site – where you can purchase Joeys online) has existing Twitter followers and notified a number of popular Raspberry Pi blog sites and posted on relevant forums.

They also sent out follow up emails, posts and tweets in the middle and towards the end of the campaign to encourage any last supporters.

The initial response was quick. It slowed right down for two weeks in the middle, then a final burst of supporters in the last week pushed it over the line.

Steve's wife has no particular interest in electronics, but it was funny how often she checked the web site to give him a progress report on how many Joeys had been backed each day.

The Joey was successfully funded in October 2015 and was in volume production by December 2015, with 165 backers from all around the world.

Although the Joey Kickstarter project itself is complete, if you need a useful display for your Raspberry Pi then the Joey boards are available for sale online at www.gooligum.com.au

So if you want to get your product out of your imagination and into the hands of customers around the world, think about giving Kickstarter a try.

You never know, it may go viral and you might end up with a high class problem of your own! SC

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Silvertone Electronics: Distributors of quality test and measurement equipment.

- **Signal Hound** - USB based spectrum analysers and tracking generators to 12GHz.
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- **Bitscope Logic Probes** - 100MHz bandwidth mixed signal scope and waveform generator.
- Firetail and Firetail Diamond UAV autopilot systems.

Manufacturer of the Flamingo 25kg fixed-wing UAV. Payload integration services available.

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February 2016

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X 0224

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Add Bluetooth® streaming to any amplifier instantly!

Pairs with your phone to stream your favourite tunes to your existing audio system... Includes 3.5mm lead. Buy P 6020 1.5m lead to hook up to RCA input on most amps ($6). USB 5V 1A charging output.

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2 x 50W Stereo Mini Amp

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W 0884A

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D 0508

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Must have for tradies, travellers and hikers. Water and dust proof battery bank to recharge your phone on the go! 5V 1A output, 5600mAH.

Q 1281

Instant-Read IR Thermometer

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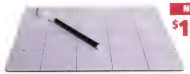
Great for the kitchen or test bench! 0.1° accuracy from -50 to 260°C. Includes batteries.



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$13.65

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This magnetic workmat keeps those tiny screws and washers in place when servicing. 25x20cm. Includes marker.

SAVE 25%

T 2185

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Ideal for servicing comms & digital devices etc. Features a driver handle & 19 interchangeable, pozi, hex, torx and blade tips.

BARGAIN!

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T 2164

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Everything you need to disassemble and repair most smartphones and tablets. Great for DIY screen or battery replacement.

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T 2367

$39

Nifty Multi-Angle Bench Vice

Made from diecast alloy. Clamps to your work bench and provides total 360° freedom when working. Jaws open to 55 mm. Includes soft jaws for holding delicate connectors.

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Tests 13 types of leads for continuity. Great time saver! **Tests:** 6.35mm, DIN (3/5/7/8 pin), RCA, XLR (3/5 pin), speakon (4P/8P), RJ45, USB & figure 8.

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Q 2022

SAVE $50

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D 2811

Turn a dumb telly into a smart telly!

Simply plugs into a spare HDMI input and provides a tablet style interface for accessing Netflix, Stan, catch up TV apps and more! Streams 1080p HD video over wireless. 1GB of RAM, 4GB internal memory & micro SD slot. Android 4.2.

Instant sound system!

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$165

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Top Deals in AV Gear!

Introducing HiFiBerry - The Audiophile Add-On for Raspberry Pi

HiFiBerry

HiFiBerry adds high-quality sound to your Raspberry Pi. HiFiBerry sound cards are designed for optimal sound output quality. It is the ideal solution for all Raspberry Pi users that love music. HiFiBerry boards are compatible with Raspberry Pi A+, B+ and 2B. **Z 6302A Raspberry Pi 2 $75.95.**

$88.95 NEW!

Z 6400

DAC+ RCA HiFiBerry Module

The HiFiBerry DAC+ is a high-resolution digital-to-analog converter. This is a special sound card for the Raspberry Pi optimized for the best possible audio playback quality.

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Digi+ HiFiBerry Module

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$146 NEW!

Z 6404

Amp+ HiFiBerry Module

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S 9423A

3.5" Colour Reversing Camera Kit

A must have for hassle free reversing with or without a trailer! Weatherproof 120° camera fits into the number plate recess. Includes a 5m lead. Make it wireless with S 8761 2.4GHz transceiver kit, $49.95.

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A 1100

NEW!

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In-built FM tuner & USB/SD card music input

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NEW!

A 3216A

HANDY!

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- Pre-programmed with 1000's of codes, plus IR learning. • Actual size: 284 x 128mm. • Requires 2xAA batteries (S 4906 lithium $4.95)

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A 0977A

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A 2554

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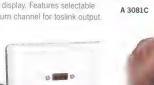

SAVE 25%

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P 5970

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Electrocardiogram Arduino UNO Shield Kit

(SC Oct' 2015) An easy-to-build Arduino project which will let you take your own electrocardiogram (ECG) and display it on a laptop PC. The software lets you read, display, save and print the electrical waveform generated by your heart – or anyone elses. Requires Arduino UNO

K 2523 **$59.95** NEW KIT!

K 9350 **$129** NEW KIT!

Control access by the press of a finger.

(SC Nov' 2015) The Fingerprint Access Controller stores and recognises up to 20 prints and provides quick access for authorised people. An indoor control-panel allows easy setup of the system, while the fingerprint reader is mounted in the supplied wall-plate.

Z 6349 NEW! **$24.95**

ATMega328P Lilypad Board

Great for moving UNO based designs & code into e-textile projects. Can be used with Z 6368 LED sequins ($4.95 5pk).

NEW! **$14.95** Z 6345

Screen & Keyboard Shield

A 16x2 black character screen with green backlight. Push buttons are provided for up, down, left, right and select. Ideal for scrolling and selecting menu options.

NEW! **$21.95** Z 6339

DC-DC Boost Module

Allows a low input voltage to be increased to a higher output voltage. Display shows input & output voltages. Input 3-34V DC. Output 4-35V DC. 2A continuous current.

Tinker, invent and design with over 70 new shields, sensors and development boards in stock!

Z 6346 NEW! **$24.95**

ATMega32U4 Lilypad Board

The 'lilypad' form factor allows easy building of sewable electronics and e-textile projects. Can be used with Z 6368 LED sequins ($4.95 5pk).

NEW! **$24.95** Z 6343

L298 H-Bridge Motor Shield

Uses an L298 H-Bridge designed to drive relays, solenoids, DC and stepping motors. It can also drive two independent DC motors. Standard Arduino shield dimensions. 5V input

NEW! **$19.95** Z 6337

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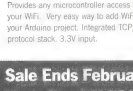
Utilises the LM2596S and LM2577 to accept a 3.5-28V input and output 1.25-24V at a max current of 1A. Ideal for projects where regulated power is required.



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Breadboard Power Supply

Makes the most of your breadboard space. Switch selectable voltage. USB 5V or 6-12V input via 2.1mm DC jack.

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Gamepad Joystick Shield

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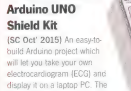
NEW! **$14.95** Z 6348

Nokia 5110 LCD Screen

Re-create classic Nokia games or code your own with this backlit LCD. 3V3 or 5V DC. Plugs into gamepad shield on the left.



NEW! **$15.95** Z 6360

ESP8266 WiFi Module

802.11b/g/n serial to WiFi Module. Provides any microcontroller access to your WiFi. Very easy way to add WiFi to your Arduino project. Integrated TCP/IP protocol stack. 3.3V input.

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Allows you to connect USB peripherals & mass storage devices to your Arduino. Uses the MAX3421E chip. Fitted with stackable connectors.

NEW! **$5.95** Z 6364

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Digitally-controlled audio preamplifier with four stereo inputs

This relatively simple circuit uses three relays and six ICs to provide digital volume control as well as switching between four stereo input pairs. Its performance has not been measured but low-distortion/low-noise components have been used.

A PCB design, in EAGLE file format, is available. It mostly uses SMDs with some through-hole components (connectors, electrolytic capacitors, op amps, regulators and relays).

Each stereo signal input is AC-coupled to a pair of relay contacts using back-to-back 47µF electrolytic capacitors. This arrangement is both cheaper and smaller than non-polarised electrolytics and the impedance is low enough that it won't distort the signal. Signal DC bias is provided by 47kΩ resistors to ground.

The relays are 5V dual coil latching types to minimise standing current drain. The prototype used parts from Futurlec (LATCHREL5V). Depending on the state of the relays, one of inputs 1-4 is routed to the common terminals of RLY3 and the stereo signals are then buffered by low distortion dual JFET-input op amp IC2. IC2 drives the signal inputs of stereo logarithmic volume control IC3, also available from Futurlec in an SMD (SOIC) package.

IC3 is controlled by signals from microcontroller IC1 via its CLK, LOAD/SHIFT and DATA IN inputs (pins 9, 10 & 11). Op amp IC2 runs from a ±15V supply for best performance while the volume control IC runs from ±6V rails, as this is its recommended supply voltage. IC3 can provide attenuation from 0-78dB, in 0.5dB steps up to 47.5dB and 1dB steps from 48dB to 78dB. It also provides a 104dB mute function.

The attenuated signal is then fed to the non-inverting inputs of IC4a and IC4b, each operating with a gain of two, giving the overall unit the capability of a gain setting between -75dB and +3dB. It's important that IC4 is a JFET-input op amp as the output impedance of IC3 varies with the volume setting. If a bipolar op amp is used, there could be audible clicks when the volume level is changed.

The buffered and amplified signals from IC4 are fed to the output sockets via 100Ω isolating resistors which prevent instability due to load capacitance in the driven device, as well as providing short-circuit/overload protection for IC4.

Microcontroller IC1 drives the coils of relays RLY1-3 using IC5, a 7-Darlington transistor array, using its PC0-PC5 digital outputs on pins 23-28. It also drives three status LEDs directly. LED1 indicates whether the unit is operating or in standby, LED2 indicates mute and LED3 flashes to acknowledge a received infrared code.

Note that the LEDs are mounted off-board via a pin header, not shown on the circuit. Similarly, all RCA sockets are chassis-mounted and wired back to 3-way polarised headers on the PCB, with the common ground connection at centre in each case.

Infrared signals are received by

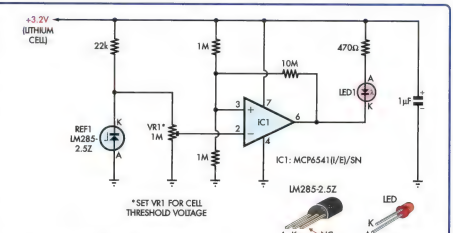
continued on page 72

Low voltage warning for a lithium cell

This circuit was devised to provide a low battery warning for cell voltages below 3V. It uses an MCP6541 micro-power comparator (IC1) and an LM285 2.5V reference (REF1) which is fed with a nominal 32µA via a 22kΩ resistor.

IC1 is connected as an inverting Schmitt trigger that compares the voltage from trimpot VR1 with a portion of the cell voltage fed via the associated voltage divider to its non-inverting input at pin 3. If the cell voltage is low, pin 3 will be below pin 2 and the comparator's output at pin 6 will go low, turning on LED1.

The 10MΩ resistor connected between pins 3 & 6 provides a small amount of hysteresis of around 150mV to prevent the LED flickering on and off at the threshold set by VR1.



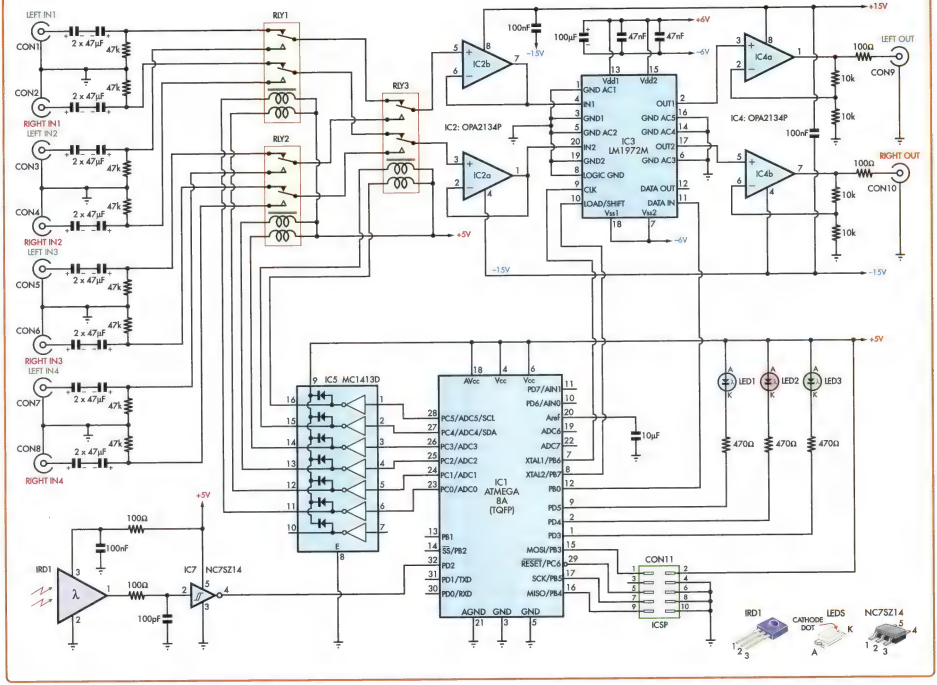
A high-brightness red or green LED should be used as the current is only 2mA and the voltage available to drive the LED is lower that that required for a white or blue LED.

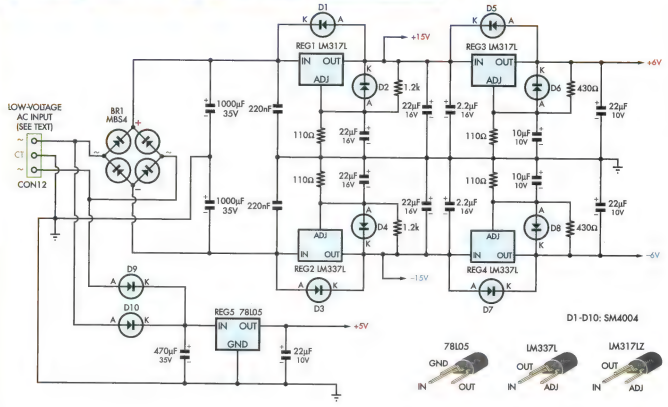
The key parts are available from the following two companies:

(1) LM285-2.5Z – Jaycar Cat. ZV-1626 (www.jaycar.com.au)

(2) MCP6541(I/E) SN – element14 Cat. 1557429 (au.element14.com)

John Clarke,
Silicon Chip.


LEFT IN1
CON1
2 x 47µF
47k
CON2
RIGHT IN1
LEFT IN2
CON3
CON4
RIGHT IN2
LEFT IN3
CON5
CON6
RIGHT IN3
LEFT IN4
CON7
CON8
RIGHT IN4
RLY1
RLY2
RLY3
IC2: OPA2134P
IC2b
IC2a
100nF
100µF
47nF
+6V
-6V
+15V
-15V
IC3
LM1972M
Vdd1
Vdd2
GND AC1
IN1
GND1
GND AC2
IN2
GND2
LOGIC GND
CLK
LOAD/SHIFT
OUT1
GND AC5
GND AC4
OUT2
GND AC3
DATA OUT
DATA IN
Vss1
Vss2
IC4a
IC4b
IC4: OPA2134P
LEFT OUT
RIGHT OUT
CON9
CON10
100Ω
10k
IC5 MC1413D
IC1
ATMEGA
8A
(TQFP)
AVcc
Vcc
AGND
GND
PC5/ADC5/SCL
PC4/ADC4/SDA
PC3/ADC3
PC2/ADC2
PC1/ADC1
PC0/ADC0
PB1
SS/PB2
PD2
PD1/TXD
PD0/RXD
PD7/AIN1
PD6/AIN0
Aref
ADC6
ADC7
XTAL1/PB6
XTAL2/PB7
PB0
PD5
PD4
PD3
MOSI/PB3
RESET/PC6
SCK/PB5
MISO/PB4
10µF
LED1
LED2
LED3
470Ω
CON11
ICSP
IRD1
IC7
NC7SZ14
100nF
100pF
CATHODE
DOT
LEDS



Audio preamp . . . continued from page 70

IRD1 and pass through a de-glitching RC filter which removes very brief spikes, followed by Schmitt trigger inverter IC7 which also helps to eliminate noise and glitches in the received signal. Its output then goes to input PD2 on IC1 which is used to trigger an interrupt service routing to process and decode infrared signals.

Power for the unit is provided by a small 15-0-15V transformer or a 15V AC plugpack (the prototype used the latter). If using a plugpack, connect it between the CT terminal of CON12 and either end. BR1 then operates as a full-wave voltage doubler.

By contrast, if a centre-tapped transformer is used, all four diodes in BR1 will conduct and it will operate as a full wave bridge rectifier.

The 1000µF capacitors are charged up to roughly ±20V and this is regulated to ±15V by REG1 and REG2. The LM317L and LM337L are used due to their superior 50/100Hz ripple rejection thanks to the 22µF capacitors between the ADJ pins and ground. D1-D4 protect these regulators from reverse current at switch-off.

The ±15V rails power op amps IC2 and IC4 directly and also feed into regulators REG3 and REG4 which are identical to REG1 and REG2 except that they are configured for output voltages of ±6V, to suit IC3.

A fifth regulator, REG5, is used to provide the digital +5V supply. This is fed by separate rectifier diodes D9 and D10 and it also has its own 470µF storage capacitor. This is to reduce the possibility of digital switching noise getting into the analog power supply.

The analog and digital grounds are joined using a 0Ω resistor on the underside of the PCB, to ensure this only happens at one point. The 5V regulator and its output filter capacitor are also on the underside. All other components are on the top side.

The EAGLE schematic and PCB design files are available for download from the SILICON CHIP website, along with the microcontroller C source code and HEX file.

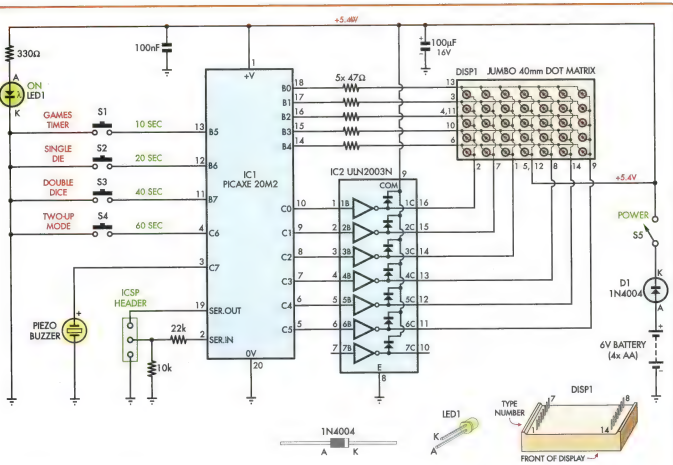
Nicholas Vinen,
SILICON CHIP.

Combined games timer & electronic dice

This device features four programs, each controlled by one of four pushbuttons (S1-S4). A games timer program limits the time allowed for each move in chess or other games.

Single and double dice programs have traditional dot faces and suit many board games, while the two-up program has a heads and tails display, based on the original coin tossing game. The unit is battery powered and includes a power switch (S5) and a power indicator (LED1). Diode D1 drops the voltage to just over 5V and also provides reverse battery protection.

The circuit includes a PICAXE 20M2 microcontroller (IC1) and has a 5x7 dot matrix LED display (DISP1), mounted sideways and driven as two separate 3x5 dot matrix displays. The five anode pins have 47Ω series resistors and are driven directly by IC1's outputs. The



six cathode pins are controlled by IC1, using a ULN2003N device (IC2) as a driver. It has multiple open-collector Darlington transistors to sink current from the six cathodes.

A suitable dot matrix display module is the Altronics Z0197 which has high-intensity red LEDs.

Holding one of the pushbuttons down while turning the power on will load a "default move time" into EEPROM. Use S1 for 10 seconds, S2 for 20 seconds, S3 for 40 seconds and S4 for 60 seconds. This time is saved until changed. With the power switched on, the same pushbuttons select one of four programs. These are: S1 games timer; S2: single die; S3: double dice and S4: two-up.

To increase battery life, the dot matrix display is blank until one of the buttons is pressed. Sound effects are provided by a piezo transducer (Altronics S6140) from pin 3 of IC1.

To select games timer mode, a player presses timer button S1 and the time will start counting down from the default move time. A player failing to complete their move before zero is reached will lose the game.

After a successful move, the player again presses the timer button, reloading the default move time, and starting the count-down for the other player. This repeats until the game is over while pressing any other button cancels the games timer. There is a clock tick as the timer counts down and a double beep if a player loses a game.

To select single or double dice modes, begin with a blank display and then push either the S2 or S3 button. You will then hear a "rolling dice sound" until the pushbutton is released. Then a random single or double dice will be displayed for three seconds before returning to the blank display.

The two-up mode is similar to dice mode, except you use button S4 and the display shows H and T characters to represent the heads and tails sides of the coin. The dice modes and the two-up mode use a more compact 3x3 matrix for all dice faces.

The games timer program uses the "time" variable in BASIC to regulate the seconds count, while the dice programs employ "for-next" loops to continually generate random numbers whenever the display is blank. This relies on the players pausing between button presses.

Four input pins on IC1 monitor pushbuttons S1-S4 and have internal pull-up resistors enabled in the software. For reliable operation use pushbuttons containing "snap action" or "tactile" mechanisms. The prototype was fitted with four Altronics S1099 pushbuttons.

The dot matrix display has 14 pins arranged in two rows of seven. The display data does not show how these pins are numbered; check the rear view of DISP1 on the circuit.

The circuit also includes an ICSP header to download software into microcontroller IC1 and uses pin 2 as the serial input and pin 19 as the serial output. You will require a special PICAXE serial or USB cable to transfer the **timer_dice20m2.bas** BASIC program – see www.picaxe.com for further information. You can download the software from www.siliconchip.com.au

Ian Robertson,
Engadine, NSW. ($70)

Pt.2 By Nicholas Vinen

High-performance stereo valve preamplifier

Having described how our new stereo valve preamp works and how to put the PCB together, now it's time to build the case. This houses the PCB so that you can still see all the components but can't touch the high-voltage sections. It's custom designed and made from clear acrylic, glued and screwed together.

THE STEREO Valve Preamplifier PCB was originally designed to fit inside a UB2 "jiffy" box. However, because it has connectors on the back and controls on the front (including a volume knob), it's pretty much impossible to actually get it inside such a box even after drilling the required holes.

Rather than compromise the practicality of the device to allow it to fit in that box, by doing something like putting the inputs on the front or side, we have designed a custom case instead. This is made in three sections which screw together so you can get it apart if necessary. We think the result is much more attractive – hopefully you'll agree after seeing the photos of the prototype.

We're using clear 3mm acrylic to show off the components and the cutting pattern is shown in Fig.8. It can be downloaded from the SILICON CHIP website (free for subscribers) in a vari-

ety of formats to suit typical laser cutter software, including AutoCad DXF.

We used a 60W CO_2 laser operating at full power and at a speed of 8mm/s (10mm/s also works but we're being a little conservative to ensure it cuts reliably).

The parts are cut from a sheet of acrylic measuring at least 230 x 315mm. The cuts shown in red are done first, in case the sheet isn't perfectly flat. In this case, if the outer sections were cut first they could shift slightly and then the inner cuts would be less accurately placed. We have optimised the cutting path to eliminate the duplication of overlapping cuts, although typical laser cutters have an extremely high degree of repeatability so this will generally not affect the quality of the end result.

The case pieces incorporate holes in the top for the valves and some cooling slots over the power supply. The front panel has holes for the power switch, volume pot, its anti-rotation tab and the two power LEDs, while the rear panel has holes for the input and output RCA sockets and the DC power connector. There are also four screw holes in the top and bottom panels corresponding to holes on the PCB, to hold the whole thing together.

If you've building the musical instrument version of the PCB with the extra panpot (VR2) and mixed output (CON5), we'll supply a modified version of the cutting diagram with these extra holes. Their locations are shown in Fig.9, relative to the pre-cut holes.

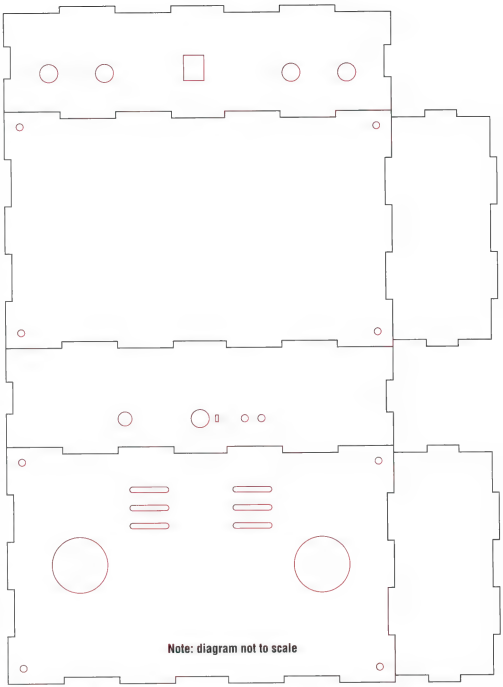


Fig.8: the laser cutting pattern used to produce the six pieces for the Stereo Valve Preamplifier case, from a 230 x 315mm piece of 3mm-thick clear acrylic (Perspex). The sections shown in red are cut first to maximise precision of the hole placement. Note the cooling slots in the top cover, which go over the power supply circuitry. The prototype lacked an onboard power switch so a hole has been added to the front panel for the final version (note: diagram not to scale).

Putting it together

You will now have the completed PCB, six case pieces (with protective film on both sides) and an assortment of machine screws, tapped spacers and feet (as specified in he parts list last month). Start by removing the two 12AX7 valves (or "vacuum tubes", if you prefer) and setting these aside so they won't get damaged. Don't put them on a surface they might roll off!

The bottom, rear and side panels of the case are glued together into one assembly which screws to the PCB. The top panel is also screwed to the PCB while the front panel is held on by the potentiometer nut(s). The PCB is sandwiched between the top panel and the bottom panel assembly and held in place with screws and spacers.

It's a good idea to check that everything will fit before gluing. Leave the protective film on the case pieces for now, so they don't get scuffed or dirty – clear acrylic shows fingerprints quite well unfortunately, so you want to avoid getting these on the inside of the case if possible, where they're hard to clean off.

Using Fig.10 as a guide, pass an M3 x 32mm machine screw through a hole in the top panel and screw on one of the shorter spacers. Do it up tight against the underside of the lid, then thread the other spacer on and repeat the procedure for the remaining corners.

Next, orientate the lid so that the valve socket holes are above the sockets, then push the protruding screw threads through the PCB mounting holes and attach the M3 x 25mm tapped

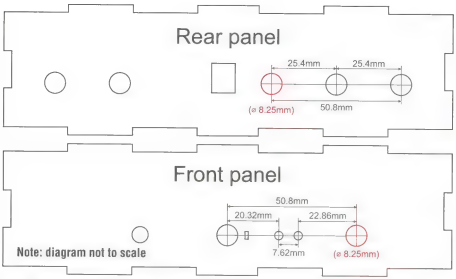


Fig.9: here's where to drill the extra holes in the rear panel (for the mixed output RCA socket, CON5) and in the front panel (for panpot VR2) if required

spacers to hold the PCB in place.

You can then screw the bottom panel on using the remaining 10mm machine screws (no need to fit feet just yet).

With the top and bottom panels held rigidly in place, check that the rear panel fits. The RCA sockets will be a relatively tight fit through the holes but assuming they have been soldered evenly, it should slide into place. Otherwise, you may need to use a tapered reamer to open the holes up slightly.

RCA sockets

Note that, on our prototype, we used the RCA sockets which are available from our online shop, because it's hard to find white sockets of this type at the usual retailers. They have a slightly different footprint but will fit on the board with some slight bending of the pins.

We mention this because this is likely to affect the height that the sockets sit at, so if you use a different type, they may not line up with the holes in the case. In that case, you would either need to adjust the RCA socket height by melting the solder joints (tricky) or simply enlarge the panel holes until they fit through.

You may find, depending on the exact height of the spacers you have used, that the rear panel will be slightly too tall to fit between the top and bottom panels. In our prototype, it was an almost an exact fit but spacer lengths can vary slightly. In this case, you may need to add some sort of a shim (eg, a washer or two) somewhere in the spacer stack to increase the gap enough for the panel to fit correctly.

Assuming it fits OK, remove the nut from the pot(s) and fit the front panel. This can be held in place temporarily with the potentiometer nut(s). If necessary, reach behind the front panel using small pliers to push the LEDs through their respective holes.

With the front and rear panels in place, it should be possible to slide the side panels into place.

Changing The Preamp's Gain

The circuit as presented last month has a maximum gain of four times (12dB). While the output swing is limited by the valve operating conditions, if you have a situation with low-level input signals, you may wish to increase this. This can be achieved by increasing the value of the 10kΩ 1W resistors to the lower left of each valve socket.

For example, using a 15kΩ resistor will give a gain of 15kΩ ÷ 3.3kΩ + 1 = 5.5 times or 15dB. A 22kΩ resistor will give 22kΩ ÷ 3.3kΩ + 1 = 7.5 times or 17.5dB. And a 30kΩ resistor gives a gain of 10 times or 20dB.

Note though that increasing the gain will slightly prejudice the performance by increasing the distortion and reducing the signal-to-noise ratio. Having said that, the performance as specified is sufficiently good that you probably won't notice the difference.

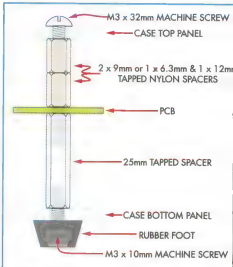


Fig.10: the top panel, bottom panel and PCB are sandwiched together using four sets of machine screws and tapped spacers. This spaces the top and bottom panels the correct distance apart for the front, back and side panels to fit. If they're too close together, add 3mm inner diameter washers in each stack as shims.

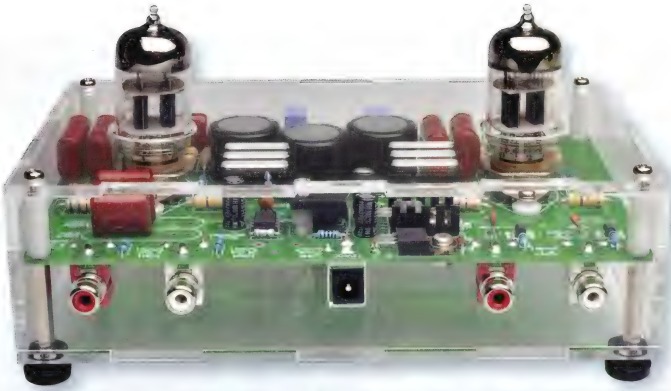
Gluing the case

Once you've confirmed that everything fits, disassemble it and peel the protective film off the pieces. Reassemble the top and bottom halves and the PCB as before, using the screws and tapped spacers, to form a rigid assembly.

The parts are glued together using a specialised, solvent-type plastic adhesive formula. We used SciGrip "Weld On" 16 fast set clear, medium-bodied solvent cement. This is available from Plastix [Sydney (02) 9599 2499, Northern Beaches (02) 9939 0555].

With a clean cloth at hand to wipe up any excess, the next step is to glue two pieces of the case together (see below) by applying a moderate amount of the adhesive to all the mating surfaces and then pressing and holding them together. Try to avoid getting any of the adhesive on the faces, especially via your fingers.

Start by gluing the rear panel to the base. Make sure it's pressed in fully until the adhesive sets (this takes a few minutes). You may find that friction holds it in for you, otherwise you



The rear panel of the case has holes for the RCA stereo input and output sockets and a square cut-out to provide access to the DC power socket. Note the ventilation slots in the top cover above regulator REG1 and Mosfet Q2.

Warning

Voltages of up to 285V DC are present on the PCB when power is applied and while ever the red LED is lit. Do not operate this unit without the top cover in place.

may have to hold it. Once it's nice and rigid, carefully unscrew the base and remove the two panels which are now joined. You can then glue the two side panels on, again making sure they are pressed in fully before it sets.

Don't use great dollops of glue but don't be too stingy either. If you're quick, you can wipe off any excess from the outside with a cloth.

Leave this assembly aside for some time (ideally, overnight) before re-fitting it using the four screws. If you have stick-on rubber feet, stick them on now, otherwise attach screw-on feet using the four mounting screws. That's what we did on the prototype (see photos).

Fitting the front panel

All that's left is to push the front panel in place, ensuring the LEDs pass through the two holes, attach the potentiometer nut and fit the knob. If you find the front panel won't sit flat, it may be that the LEDs are protruding too far and pushing on it. Pressing them carefully back into the case should fix this. You will need to do this to both LEDs or the result could look strange.

It's now ready to use. Remember that it takes 10-15 seconds each time you power it up before the HT rail rises to its normal level and all the bias voltages stabilise. Until then you aren't likely to get much output. Ideally, wait 30 seconds or so after powering up for it to achieve a reasonable level of performance. The valves will continue to warm up for some minutes and this may affect performance slightly.

Note: Altronics have announced that they are in the process of preparing a kit for this project, Cat. K5192. The plan is for it to be a complete kit, including the parts required to make the case. However, the case may not be identical to the one described here. Instructions regarding the case assembly will be supplied with the kit. **SC**

Improving The Bass Response

A reader has brought to our attention the fact that the circuit as presented last month could have a significant amount of bass attenuation when driving a fairly typical power amplifier load impedance of around 10kΩ.

This is because the 220nF output coupling capacitor is not quite large enough. Our Audio Precision test equipment has a 100kΩ input impedance and in combination with the 220nF coupling capacitor and 1MΩ onboard bias resistor, this results in a -3dB point of around 8Hz.

However, with a 10kΩ load impedance, the -3dB frequency increases by nearly a factor of 10, to 72Hz. We've confirmed this by simulating the full preamp circuit (see the graph in Ask SILICON CHIP). This is not an unrealistic load impedance; for example, our Ultra-LD Mk.2, Mk.3 & Mk.4 power amplifiers all have an input impedance of around 11.8kΩ.

The solution is simple: increase the coupling capacitor value. At the very least, use 470nF 630V capacitors (one in each channel) for a -3dB point of 34Hz for a 10kΩ load. Ideally, though, they should be at least 1μF. The simplest way to achieve this is to use pairs of parallel 470nF capacitors, one on either side of the PCB for each channel. This will yield a -3dB point below 20Hz.

Keithley's 2460 Sourcemeter

Review by Jim Rowe

The Keithley 2460 SMU (Source Measure Unit) is a programmable 100W DC power source and load combined with a 6.5-digit DMM. Most of its functions can be controlled via its large touch screen or from a PC via its USB input. As well as functioning as a DC power supply, it can be used to plot a wide range of parameters for high power semiconductor devices.

So what exactly is an SMU and what's it used for?

Well, what would you need for measuring the I/V (current/voltage) characteristics of a wide range of semiconductor devices – like diodes, bipolar transistors and Mosfets?

First, you'd need at least one accurately adjustable DC power supply or 'source', plus one or more accurate DMMs (digital multimeters) to measure the device current and voltage.

You would also need a programmable electronic load.

Combine all that and you would have something like the Keithley 2460. Not only does it have a digitally programmable DC source, a programmable electronic load and a 6.5-digit DMM, there's also a microcontroller capable of running multi-level 'sweep' scripts to measure the current drawn by the DUT (device under test) at a series of programmable voltage levels, and then displaying the results in either tabular form or as an I/V graphical plot.

It could also be used for applications like cycling of rechargeable batteries and characterisation of electrochemical deposition, corrosion and electroplating.

Most of the test parameters and settings are made via its 127mm (diagonal) touch-screen colour LCD, using a series of menu screens. The touch-screen incorporates 'swipe', 'pinch' and 'zoom' functions, for intuitive manipulation of the on-screen

A closeup of the rear of the Keithley 2460, showing the range of comms I/O connectors along the bottom and the power input at upper right. The orange terminal strip in the centre provides the alternative 'rear' test connections.

displays (just like on a smart-phone).

Capabilities

The programmable source and load can together provide full four-quadrant measurements, with a maximum source voltage of ±105V and a maximum current level of ±7A (DC or pulse). Maximum voltage and current are not available at the same time; the maximum power rating is 100W.

The 6.5-digit DMM offers a basic accuracy of 0.012%, six voltage measuring ranges covering 200.0000mV to 100.0000V full scale, with resolutions ranging from 100nV to 100µV, and 10 current measuring ranges covering from 1.000000µA to 7.000000A full scale, with resolutions ranging from 1pA to 1µA.

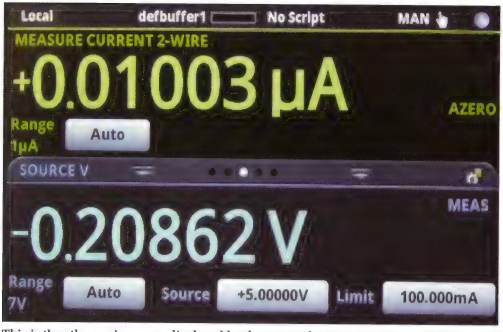
There are eight resistance measurement ranges, with either local or remote sensing, 2-wire or 4-wire measurement and full scale readings ranging from 2.000000Ω (resolution 1µΩ) to 20.0000MΩ (resolution 10Ω), plus a ninth range for values over 20MΩ using a user-defined test current.

As well as offering a wide choice of source and measurement setting options, the 2460's micro has an in-built Test Script Processor (TSP) function which allows it to run built-in scripts for multi-level 'sweeps' and I/V curve plotting. It also offers four 'Quickset' options to enable one-touch set-ups for basic measurement jobs like a voltmeter, an ammeter, an ohmmeter and an accurately programmable power supply.

Other neat features offered by the 2460 in 'local' (ie, free-standing) mode include the ability to select either continuous or single-shot testing with manual triggering via a button on the front panel, the ability to choose between test connectors on either the front or rear panels, a built-in context-sensitive help facility, the ability to choose either manual or automatic measurement ranges and also the ability to select Linear, Log, Dual Linear, Dual Log and Custom sweeps.

There's also a USB 2.0 port on the front panel for saving test scripts as well as test results to external USB memory. The connection options on the rear panel comprise an RJ-45 Ethernet connector, a USB type B socket, a female DB-9 connector for

Here's the 2460's built-in main Menu screen, used for selecting just about all of its configuration, testing and display functions via the touch-screen facility. It even provides 'swipe', 'pinch' and 'zoom' functions, like a smart-phone.



This is the other main screen displayed by the 2460 – the Home screen, used to set up, configure and numerically display the test parameters. It too makes full use of the touch-screen facility, to make testing fast and intuitive.

direct digital connections, a pair of TSP-Link connectors for linking into a multi-instrument test system and an IEEE-488 connector for GPIB interconnection.

Most users will probably want to link up the 2460 to their laptop via either USB or Ethernet, and with this in mind it comes with cables for either.

To make it possible for users to start making measurements with the 2460 as quickly as possible, it comes with a CD-ROM providing both 'Quick Start' and 'Reference' user manuals in PDF form, plus a free instrument control/startup software package called KickStart.

The latter incorporates the KickStart control application and a comms configuration manager called Keithley Configuration Panel, which is used to install and set up the various drivers needed to link the 2460 to the PC.

Part of the Configuration Panel software appears to be a subset of National Instruments' NI-VISA 5.3 Runtime, which gets installed along with it.

What we found

Initially and in order to become familiar with the 2460 and its touch-screen menu, I tried performing quick 'manual' tests like 4-wire measurements on low-value resistors and current shunts of known value. Here the results compared very closely with the readings from my Yokogawa 7562 6.5-digit DMM. However due to the extra capabilities of the 2460 I was also able to measure the variation in a shunt's resistance value as a function of current – right up to current levels of 7A. That's not something you can easily do with the 7562 alone, or with any standard DMM for that matter.

I also tried setting the Power Supply section of the 2460 to various reference DC voltages and checking its output with my trusty Yokogawa. The results were again very impressive, with the readings on the 7562 within 15 ppm of the voltage settings on the 2460. For example, a setting of '10.0000V' gave a reading of '10.00008 V', while a setting of '2.04800V' gave a reading of '2.04802 V'.

After this I tried using the 2460's built-in 'Sweep' script to check the voltage-current characteristic of various 2-terminal semiconductor devices, like a forward-biased LED, a standard 1A silicon diode and then a Schottky diode. Then I progressed to checking the reverse-biased characteristic of a 3.9V zener diode, in each case using the 2460's 'Graph' mode to plot the E/I curve directly on its screen (see the screen shots in Figs.1&2 below).

Then it was time to try linking it up to my Asus P550L i7 laptop PC, running Windows 7 Pro (64-bit). So following the instructions in Keithley's KickStart Software Quick Start Guide, I started installing the necessary software and drivers for a USB connection between the two.

This turned out to be quite a rigmarole and along the way you find yourself asked to verify your agreement with various software copyright licences – not just with Keithley, but

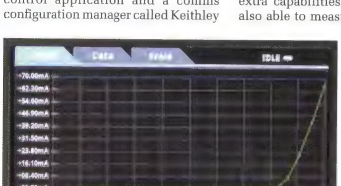


Fig.1: The E-I plot of a red LED, as displayed directly on the 2460's screen by selecting the 'Graph' tab at the top.

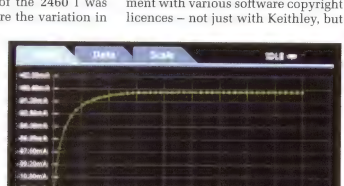


Fig.2: Again displayed directly on the 2460's screen this shows the reverse bias E-I plot for a 3.9V zener diode.

also with National Instruments and another crowd called IVI Foundation Inc.

And some of the software components seem to need you to set various options, some of which are not covered in the Quick Start Guide; not straightforward, at all!

When I thought I had installed all the software, plugged in the USB cable from the 2460 and then tried firing up the KickStart software to see if they could 'talk' to each other, they couldn't.

KickStart couldn't find the instrument at all and showed only its built-in 'virtual instrument simulations'.

Confusingly, when I went into Windows' Control Panel and then Device Manager, it was showing the 2460 as a USB Test and Measurement Device (IVI) and said it was 'working properly'.

This was promising, and when I also fired up Keithley's Configuration Panel it too showed the 2460 as hooked up and operating correctly. So why wasn't KickStart able to find it?

Hmmm – perhaps my copy of KickStart was somehow corrupted. So I tried going to the Keithley/Tektronix website and downloading a fresh copy of the latest version. Then it was a matter of uninstalling the original copy of KickStart, extracting everything from the new download and installing it all over again.

This time I also tried to stay focussed on the various options which needed to be selected during the installation – particularly those for the NI-VISA Runtime drivers. In fact I made sure that ALL of the drivers were selected for installation this time, even those that didn't seem to be appropriate when I was only preparing for USB communication.

Finally, this time KickStart was able to 'find' the 2460 SMU and I was able to try using the laptop to control the 2460 as a complete 'testing system'. Now setting up and running tests and characteristic plots for various devices proved to be even easier and more intuitive than with the 2460 by itself.

Mind you, my laptop doesn't have a touch-screen, so I had to do all of the on-screen setting up using the mouse...

Perhaps my only real criticism of KickStart is that it doesn't seem to offer much in the way of options regarding on-screen graph visibility.

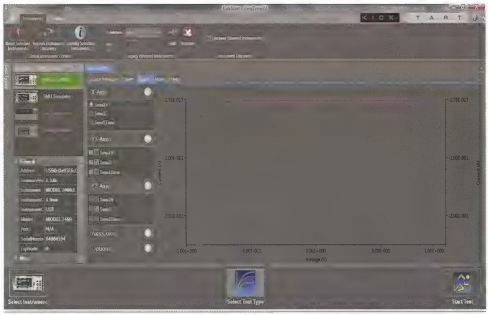


Fig.3: the KickStart software screen when showing the results of the zener diode E-I test, performed again remotely via the USB interface. Note the less than ideal graph legend visibility, due to the mid-grey background. Currently you have to export the graph as a PNG file and print it out to get full visibility.

As you can see from the screen grab of Fig.3, the graph window background seems to be fixed at a mid-grey, with the axis lines and legends in black.

Although you can change the colour of the graph plot itself for maximum visibility, this still makes it a bit difficult to read the legends.

The only way to get a really clear image of a graph seems to be to export it as a PNG image file, then import it into an image editor like Photoshop or Paint.net and either view it on screen or print it out like the graph shown in Fig.4 (below).

By the way KickStart also allows you to export test results in tabular form, in either Excel or CSV (comma separated variable) formats.

So the bottom line is that as well as having high accuracy plus measuring flexibility way beyond that of standard DMMs, the Keithley 2460 SMU is a surprisingly easy instrument to 'drive' – whether you are using it alone or hooked up to a PC running the KickStart software.

It would therefore make a good choice for anyone who needs to do a lot of characteristic curve plotting.

Where do you get it?

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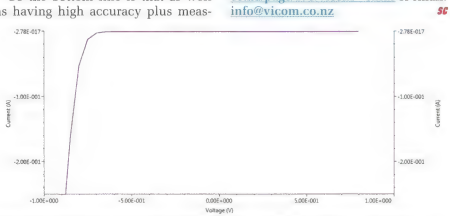


Fig.4: this printout of the above screen shows the rather dramatic difference in legibility over the on-screen view above (Fig.3). It's a shame that there is no way to adjust screen contrast, etc, to achieve a much clearer result.

Vintage Radio

By Associate Professor Graham Parslow

The 1948 Healing L502E 5-valve radio

Boasting excellent performance, the Healing L502E was released in 1948 and is a fairly conventional 5-valve superhet receiver. A number of different models share the same cabinet design, with some unusual mechanical linkages used for the on/off switch and tone controls.

AMONG MY COLLECTION of vintage radios are four Healing models which all have the same cabinet style. Two of them are model 502Es (the more common type) and these have a loop antenna coil that also serves as an inductor for the tuned RF front-end. By contrast, one of the remaining two sets, a model L502E, uses a conventional aerial coil in place of the loop antenna.

The fourth set is a battery-powered model 553A and this set uses a vibrator to generate HT from its 6V battery power supply. Healing consistently used an "A" suffix in their model numbers to designate battery-powered "farm radios" and an "E" suffix for those powered from mains electricity.

In my opinion, many vintage radio collectors progress through several phases that can be roughly summarised as tentative, then manic and finally mature. My first Healing acquisition, in my manic phase, was the model 553A farm radio, which I obtained from eBay. I confess that I was enamoured with the graceful shape of the case and the charm of the singing canary emblem.

The attractive singing canary emblem on the Healing receivers is made of enamelled brass.

That first radio was advertised with one missing control knob. This was subsequently reproduced using a plastic milk-bottle lid which just happened to have the correct dimensions and a comparable knurled edge. This lid was filled with car body filler and a hole drilled to fit the set's control shaft. The colour was carefully matched to the Bakelite by judiciously daubing the part with black and brown paint.

When that radio originally arrived by post, it was missing the knob as expected but what wasn't expected was that its valves were also missing. This was part of a learning experience to check advertised radios for the common parts that "handymen" remove and put in their junk boxes (badges, knobs and valves). Knobs removed from the sides of cabinets are particularly hard to pick from frontal pictures.

Fortunately, the Golden Voice emblem was still in place. This emblem is made of enamelled brass and cleans up well with Brasso polish.

As an aside, the phrase "Golden Voice" was also used by Motorola in the US for their radios and other equipment but the logo had a different appearance to that used by Healing. I haven't found any links behind that shared usage.

The set described here is a 1948 model 502E, made not long after World War 2. When the war ended, Healing proudly declared that "Australia's

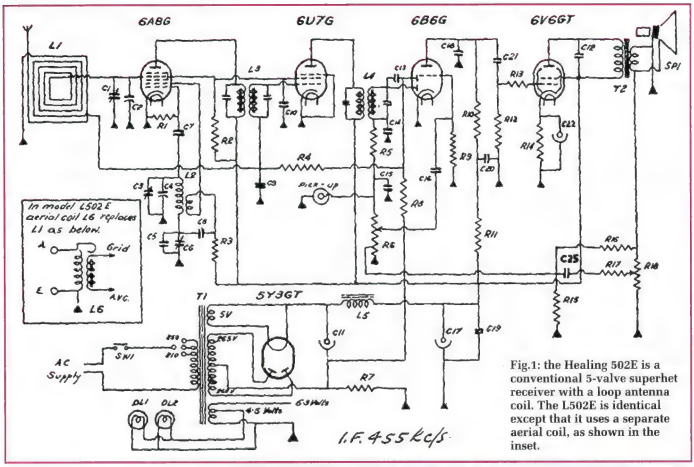
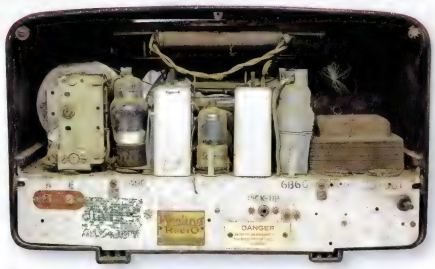


Fig.1: the Healing 502E is a conventional 5-valve superhet receiver with a loop antenna coil. The L502E is identical except that it uses a separate aerial coil, as shown in the inset.

largest manufacturer of radar receivers" was now "devoted to producing radio receivers for every Australian home. And Golden Voice is right 'Back On its Perch' at your Healing Dealer, waiting to show you just how good the much-promised post-war radios really are. In vacuum-pressed veneer consoles and rich plastic mantel cabinets, each Golden Voice Radio is a thing of beauty and, of course, unsurpassed for quality and tone".

Healing's claim of high quality and clarity of tone has some validity. Both of my model 502s give excellent reproduction from their 8-inch Rola speakers.



The author's L502E receiver prior to restoration. It was covered in dust, had missing knobs and valves, and came with spider webs and a wasp nest.

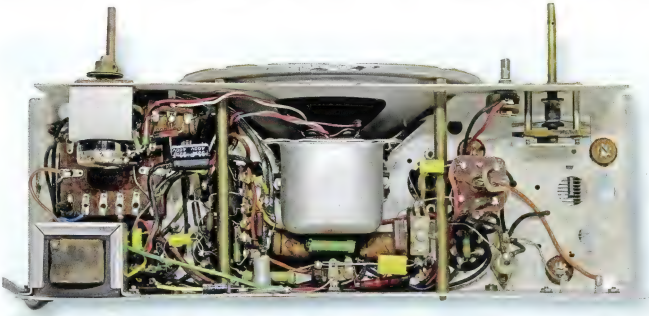
Circuit details

Fig.1 shows the circuit details of the Healing Model 502E. There are no radical surprises here and no corners were cut for the sake of economy. However, it's worth noting that, at the time, Healing also made a smaller 4-valve economy model designated the 401E. This "kitchen radio" did omit as many parts as possible to drive the cost down.

As shown in Fig.1, the Healing 502E is a fairly conventional 5-valve superhet design employing a 6A8 mixer oscillator, a 6U7 IF amplifier, a 6B6 detector/AGC/audio preamplifier, 6V6 pentode output and a 5Y3 rectifier. The tone control circuit is somewhat more complicated than usual, with feedback from the output transformer via bass control pot R18 to a tap on the volume control to provide bass boost.

An unusual feature is a 4.5VAC tap on the 6.3V transformer secondary winding to power the two 6.3V dial lamps. This presumably extended the life of the dial lamps which are mounted behind the rear edge of the plastic dial face. The lighting is rather dull as a result of this arrangement but still perfectly OK in a dark room.

Running the lamps at less than their rated voltage may have extended their



This view shows the 502E after the under-chassis restoration work had been completed. Some parts are difficult to access as they are buried under other components.

life but it certainly wasn't indefinite. The two sets in my collection both came with darkened open-circuit lamps.

As with many similar sets, the 502E has a gramophone "pick-up", with the signal fed in via an RCA-type socket in the middle-rear of the chassis to the top of the volume control pot. There is no provision to mute the radio section when it is used with a gramophone pick-up though, so presumably it was just a matter of the user tuning off-station, to a quiet part of the dial.

The four control knobs have a twin concentric configuration and are used for power on-off switching, volume control, tone control and tuning. Switch pots weren't common at the time and so the 502 uses an articulated linkage to connect the rotary outer righthand control shaft to a rotary switch for the mains power. The righthand central control shaft is used for tuning.

A mechanical linkage is also present on the lefthand side, with the outer control shaft fitted with a friction wheel. This in turn drives a wheel on the shaft of the separate tone control pot. The lefthand central shaft controls the volume pot. Basically, the engineering techniques used for these controls were driven by the aesthetics of the case design.

Restoration

The Healing L502E in the photos is the most recently acquired of my four Healings and came from a deceased estate. It's fair to say that its previous owner was more a hoarder than a collector. Many sets in his collection had been tinkered with and then sent to ignominious storage on dusty shelves.

When I acquired it, the L502E was missing all its knobs but came complete with spider webs and a rock-like mud-wasp nest between the tuning gang and the chassis. This wasp's nest had penetrated between the vanes of the tuning gang but I was able to remove it using a stiff wire brush.

Unfortunately, the set's exposed steel surfaces all showed significant rust, including on the tuning gang, the dial light enclosure and the mains transformer casing. These rusted surfaces were all abrasively cleaned and painted to match the original finish.

The folded metal chassis didn't have any rust because it is made of aluminium. However, the aluminium had degraded in many places to either an oxide or salts of aluminium. A good clean-up using scrapers and steel wool restored a gleam to most of this metalwork.

This front view of a 502E chassis shows the unusual curved dial-face and the mechanical linkages used for the on/off switch (right) and the tone control (left).

Missing valves

Having completed the chassis clean-up, it was time to restore the circuit to working order. Both the 6V6 and 5Y3 valves had been removed from the radio. At first, I thought that they might have been removed for use in another radio. However, the collection this radio came from included a number of valve testers, so it was more than likely that these valves had been removed for testing and had failed.

The 502E chassis is easily identified by the loop antenna coil next to the tuning gang. There's also a hole in the chassis where the aerial coil would otherwise be installed.

A look under the chassis soon reinforced this latter theory. The underchassis layout is crowded and this makes it difficult to replace certain parts. In particular, the HT filter choke (L5) blocks access to components around the 6V6 and 5Y3 valves, so I removed it for the duration of the restoration. That choke was clearly stamped with the date "22 OCT 1948".

Once it was out, the cause of the two valve failures could be readily explained by the state of paper capacitors C12 (0.01µF) and C21 (0.02µF). C12, in particular, had been deformed by heat into an almost unrecognisable blob with fly leads extending from it.

This capacitor is paralleled across the output transformer's primary, its role being to bypass high frequencies beyond the normal audible range. Because C12 and T2 form an LC circuit, I suspect that, as the capacitor deteriorated, it caused the 6V6 audio output stage to oscillate, resulting in high power dissipation. However, C21 was probably the main reason the two valves failed.

C21's failure is unremarkable, since it's used as a coupling capacitor between the 6B6 preamplifier and the 6V6 output stage and is subjected to a high DC voltage. In fact, any paper capacitor used in this role should be routinely replaced due to the high probability of DC leakage.

The evident failure of C21 in this Healing set would have resulted in a high positive grid bias on the 6V6. This in turn lead to the destruction of both the 6V6 and the 5Y3 rectifier which supplies the current. Fortunately, when the 6V6 failed, the output transformer remained intact.

C22 had deteriorated so badly that it had lost its outer wrapping and so its value was no longer visible. This capacitor functions as a cathode bypass on the 6V6 and so a new 22µF

The model L502E uses a conventional aerial coil instead of the loop antenna coil used in the 502E. It's shown here nestled between the first IF coil and the loudspeaker (ie, immediately behind the tuning condenser and the 6A8 mixer-oscillator valve).

The Healing 502E & L502E sets carried a "Pick-Up" socket on the rear of the chassis so that a turntable could be plugged in. There was no provision to mute the radio section when this was done though.

40V electrolytic was installed in this location. The two HT filter electrolytics were also replaced with new capacitors.

Paper capacitors C20, C8 and C19 all showed signs of failure at their pitch-filled ends and so these too were replaced. The remaining capacitors were buried under wiring and other components and were left in place for the time being. The idea was to replace individual capacitors later only if that proved necessary.

Apart from the difficulty of doing so, there is a good argument for not replacing all of the original capacitors. Component failure is most likely in the initial operating period if there is a defect and any parts that pass soak-testing can be left in place.

It's worth noting here that the debacle of failing electrolytics in the early 2000s has now passed into history. Those failures were attributable to inappropriate aqueous electrolyte mixtures that are no longer used.

The replacement capacitors used for this restoration were sourced from the component bank of the Historical Radio Society of Australia (HRSA), a service which is only available to members. However, 630V polyester capacitors are readily available from Jaycar. Replacement 6V6 and 5Y3 valves for this radio were also obtained from the HRSA.

The broken dial cord was replaced with some difficulty, due to three separate turns being required around the dial drum. In addition, the mains on-off toggle switch of this radio did not switch off, so it was bypassed.

The last bit of preparatory wiring, prior to switch-on, was to replace the dilapidated twin-core (figure-8) mains lead a 3-core flex so that the chassis could be securely earthed. The original figure-8 was retained by a knot inside the chassis which is now illegal. As a result, the replacement mains cable was firmly secured to the chassis with an approved clamp.

Applying power

Next, the valves were all removed and the power applied. The dial lights glowed encouragingly, the set's power consumption was around the expected 10W and the transformer stayed cool. The rewired chassis looked like it had a fair chance of working at switch on once the valves had been reinstalled and an antenna connected.

For once, my optimism proved to be well-founded. I applied power and was rewarded a short time later with some low-level hum and then a slightly off-station signal. I corrected the tuning and then tuned right across the dial. Everything worked fine, the radio sounded great and the power consumption settled at a steady 55W.

Cabinet restoration

The cabinet looked exactly as you would expect it to look after languishing on a dusty shelf for many years. A quick clean up with some warm soapy water and a silicone car polish soon brought out the hidden beauty, after which the torn grille fabric was replaced with new material.

The plastic speaker grille at the front of the cabinet was straightened with the aid of carefully applied heat from a heat-gun. This wasn't completely successful but the end result was quite passable and it certainly looked a lot better than it did before. Unfortunately, a distorted speaker grille is a near-universal feature on the cabinets of these old Healing radios.

Another problem was that the sleeve and friction drive for the tone control was absent. As a result, the tone control was simply set to an agreeable setting and left at that setting. Two large knobs that covered the case holes were then installed for volume and tuning. Perhaps a genuine knob set will turn up for this radio in the future, although I have yet to see any of these unique knobs for sale. SC

A Brief History Of A. G. Healing & Co

A. G. Healing was founded by Alfred George Healing who was born in 1868 in Richmond, Victoria. In 1898, at the age of 30, Healing obtained the Victorian agency for the English Haddon bicycle and operated as A. G. Healing & Company in a small factory and shop in Bridge Road, Richmond.

In 1921 the factory was relocated to the corner of Queensbury and Elizabeth Streets, Melbourne. The staff grew to about 50 and 25,000 bicycles were made per year at the peak of production, with sales to all states.

In 1925, Healing diversified into radio manufacture. They also simultaneously imported Atwater-Kent radios from the US but tariffs and limits on imports eventually saw the company discontinue this brand.

The most highly-valued radio in the Healing line-up is the 403E "Scales" model (SILICON CHIP, March 2006), a 4-valve set which sold from the late 1940s to the early 1950s. The company survived into the TV era and in 1959, the electronics division became part of Rank Industries. It ceased manufacturing in 1975.

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QUIZZICAL QUIZ GAME	OCT 2011	08110111	$25.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$30.00
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$20.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01212112/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201122/3	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMITEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMITEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMITEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04110121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$30.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY·TIM AMPLIFIER (same PCB as Headphone Amp [Sept11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender MK2	JAN 2014	01112131	$15.00
Li'l Pulser MK2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$12.50
NICAD/NiMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$5.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141ab	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MEMOTHER	AUG 2014	24108141	$5.00
OPTO-THERMEMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	OCT 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$5.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	-	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$5.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7. 50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101141	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	15105151	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$5.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE-LIGHT SPEEDUP	JAN 2016	05102161	$15.00

NEW…THIS…MONTH

SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB 2016	07102122	$7.50

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Improving the bass of the valve preamplifier

Your valve preamplifier in the January 2016 issue is a great project and I'm interested in building one to try the "valve sound" for myself. I've tried many op amp and discrete semiconductor preamp designs over the years and have tended to prefer the sound of simpler designs based around a complementary-feedback pair of bipolar transistors or discrete op amp types over the ultra-low THD op amp versions, so I expect to like the valves.

There is a key specification missing in the article though: the preamplifier's output impedance. Is it low enough to drive a solid-state power amplifier's input?

Certainly, the output coupling capacitor is far too small. With a power amplifier input impedance, of say, 10kΩ, the -3dB point is about 72Hz with the 0.22µF value used. How many builders are going to try it in their system and conclude that valves are no good for bass? Surely at least 1µF and preferably 2µF would be more like it?

While I admire your clever design of efficient power supplies, I'm not keen on the use of a switching supply so close to the signal stages; especially one running only just above the audio band at 100kHz. There are small isolation transformers available with 230VAC output that could provide a simpler linear solution for the HT, eg, Hammond 185d230, available from E14 or Mouser for about $27.

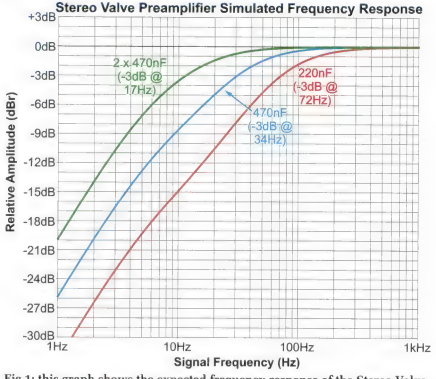

Fig.1: this graph shows the expected frequency response of the Stereo Valve Preamplifier with different output coupling capacitors.

Using USB TV Dongle To Measure Signal Strength

We have moved into a rental property while our new house is being built but the TV signal quality here is not good. That had me thinking. Why not use a USB TV dongle to measure signal strength and signal quality?

Signal quality (BER, MER) is important, maybe more so than just signal strength for digital TV. I thought that nowadays with the internet and the TV dongle, I would be surprised if someone has not written some software for the TV dongle, to allow it to be used for aiming and testing a TV antenna. Maybe a SILICON CHIP article on using such a dongle would be a good idea?

There may be other software than just the following:

(1) www.hauppauge.co.uk/forum/showthread.php?22274-Standalone-DVB-T-Signal-Strength-Quality-Utility&p=103508

(2) www.dvbtmeter.com/2010/02/digimax-dvb-t-meter-scanner-pro.html?m=1

You have had a few antenna articles. A follow-up antenna setting-up article would be good. (R. W., via email).

● The software supplied with most USB TV dongles already has an in-built display of signal strength when you select a station. Or if not, it will display signal strength and quality when you do the initial scan for stations. You can see more detail on this in the article on USB TV dongles in the April 2013 issue.

You can see a free 2-page preview of this article at: www.siliconchip.com.au/Issue/2013/April/How+To+Get+Digital+TV+On+Your+Laptop+Or+PC

However, since you have raised the topic, it seems as though we should revisit USB TV dongles to assess how they handle HD MPEG-4 transmissions from the Nine & Seven networks. We will do this sometime during 2016.

LED Replacements For 12V 100W Halogen Lamps

I have just replaced some of the 100W halogen bulbs in my pool lights, a less than bi-annual maintenance task. Not for the first time have I wondered that it would be great to replace these halogen lamps with LED arrays that give a similar light output.

I could be wrong but there must be many other pool owners who have similar light fittings running off 12V isolation transformers with small format halogens that will always eventually burn themselves to death.

Replacing these halogen lamp fittings completely with newer LED fittings is not that easy as the wiring and brackets to hold the lamps are all underwater. Spending a little money to replace the halogens with LEDs inside the same fittings, knowing that they will last a long time, would certainly motivate me.

My lamp fittings easily have 100mm diameter of clear space that would fit a PCB populated with several LED devices, I expect many others are similar. If it is all sounding too easy and you are yawning into your coffee, maybe a multi-colour LED system toggled by activating the on/off switch multiple times (eg, first toggle-natural, second-blue, third-green etc)? (P. M., via email).

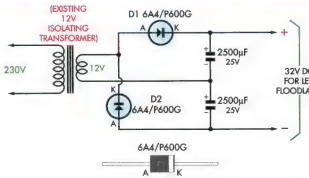

Fig.2: this voltage doubler circuit can be used to power a 32V LED floodlamp.

- You can buy LED replacement pool lighting but as you have probably found, it is very expensive. As an alternative, it should be possible to adapt typical 20W or higher rated LED chips to your floodlights. These normally run from a mains-driven constant current driver (see www.ebay.com.au/itm/LED-Beads-Chip-Driver-85V-265V-Waterproof-Constant-Current-10W-20W-30W-50W-100W-/321685019430?) but we would not recommend these for use in a pool application because there is no guarantee that they have adequate insulation.

They drive the LED array at about 32V DC so we would suggest that you adapt your existing 12V isolation transformer(s) to the task with the aid of a half-wave voltage doubler power supply consisting of two high current diodes and two 2500µF 25V electrolytic capacitors. This should be adequate to drive a 20W LED chip.

The suggested circuit arrangement is shown above as Fig.2.

I also have to say your PCB looks like a lot of it was done by an autorouter. Hence I'm thinking to build a hard-wired version on tag strip with my own simpler power supplies and internal power transformers – the design is simple enough for this to work well I think.

Another thing: the low dropout regulator on the heater supply is quite expensive and hard to get. Would not a 7812 work just as well, providing the input voltage is always above 15V DC?

Keep up the great work and thanks as always for a fantastic magazine. (I. B., via email).

- That's a very good point about the size of the output coupling capacitors and it's a bit of an oversight on our part. However, it is easily fixed, as you can substitute two 470nF/630V capacitors for the 220nF capacitors in each channel. You can install one above and one below the PCB.

We ran a circuit simulation to check the likely performance with one or two 470nF output coupling capacitors feeding a load of 10kΩ and as you can see in the diagram of Fig.1, a 470nF capacitor results in a -3dB point of 34Hz while two 470nF capacitors result in a -3dB point of 17Hz (as you suggested).

The output impedance of the preamplifier is lower than you might expect, at less than 200Ω. That is a beneficial side effect of the relatively high negative feedback in the circuit and it means that long output cables from the preamplifier will cause negligible high frequency loss. It certainly is more than low enough to drive the input of any amplifier that you are likely to consider.

As far as the power supply is concerned, do not worry about the fact that it is a switching design. The key figure to watch is the signal-to-noise ratio: -105dB is exceptional for a valve preamplifier and pretty good for all but the best solid-state preamps. We would suggest that you build the preamp as described initially. If you don't like the result, you can always substitute an analog supply later.

The PCB layout was most definitely not done by an auto-router. It was a human router (one Nicholas Vinen, in fact) and the decisions about how to run signal lines and general layout were quite painstaking, all with high performance in mind. There is simply no way in which you would get the same performance from a hand-wired layout using tagstrip or tag-board. Consider: this is 2016, not 1956!

As far as the regulator is concerned, a 7812 would give the same performance as the LM2940, provided the input supply was above 15V DC. However, we wanted to make the preamp compatible, as far as possible, with 12V plugpack supplies and that would not have been workable with the 7812.

In any case, compared with the likely cost of the valves, the bigger capacitors, PCB and case, the cost the specified regulator is not really significant.

By the way, Altronics will have this preamp available as a kit.

Fingerprint security question

I would like to ask a couple of questions about the Fingerprint Security project in the November 2015 issue.

I have built the main and switch

Balanced Cables Should Solve RF Breakthough Problem

I recently gave a talk to ARNSW concerning the early days of military communications. Unfortunately, the local conditions at Dural had a severe impact on the presentation.

Specifically, the hum loop between my laptop and the self-contained amplifier speaker created acoustic interference that was intolerable and we had to rely on the tiny speaker in the computer. This was very frustrating as I have not had this problem with a number of previous presentations in other less RF-prone locations.

The configuration in use was with the audio output port from the laptop connected via a short patch cable to the amplifier input and both power cables connected to a common patch board linked to the local power supply. Evidently, the high level of RF at this site assisted the establishment of a very strong "hum loop", with serious results.

I could probably solve this problem by using a self-contained battery-powered audio amplifier but the small speaker size and low power output renders that solution unattractive.

I also assume the problem could be solved by effectively disconnecting the computer's audio output from the input to the amplifier with the introduction of an optocoupler device and I wonder if SILICON CHIP has ever done such a project. A simple mono input and mono output with the optocoupler connection between and battery-powered would solve this problem, I assume.

If you have ever done such a project, I would be very grateful if you could advise me as I would not want to be caught out this way again. It was highly embarrassing and frustrating but fortunately the audience was remarkably tolerant notwithstanding. (P. J., via email).

● We have not done such a project as it would require an ADC with Toslink optical output and a matching DAC. There are suitable Jaycar products to do this (Cat AC-1631 and AC-1596) but the all-up cost of such a link is about $130.

However, we would suggest that you try a balanced line connection between your laptop and amplifier. To make a balanced line connection between the audio output of your laptop and the input of your amplifier you will need a balanced line transformer at either end of the connection.

You can see how to do this in the article on a Passive DI Box in the October 2014 issue. Each DI Box uses a Mu-metal shielded transformer from Altronics (Cat M-0705).

You can see a 2-page preview of the article at www.siliconchip.com.au/Issue/2014/October/Passive+Direct+Injection+%28DI%29+Box

PCBs while waiting for the FPS module to arrive. During the building I noticed that there seems to be a discrepancy in one of the resistor values between the circuit diagram and the value silk-screened on the PCB. The resistor in question feeds pin 4 of the PIC16F88 from the +5V rail and is shown as 1kΩ on the circuit diagram but is shown as 10kΩ on the silk-screened overlay.

I have assumed that the correct value is 1kΩ as shown in the circuit. However, when I tested the unit, minus the FPS module, I get no reading/text on the LCD screen, only black squares when the contrast pot is turned up full.

Will I need to have the FPS module connected for this to show something on the screen? I programmed the PIC16F88 using the PICkit 2 and it programmed successfully and also verified correctly. I have exactly 5V between pins 5 and 14 on the PIC. The PCB I have is revision B. (P. C., via email).

● You can use either a 1kΩ or 10kΩ resistor; it does not matter which.

For the screen, check that you have soldered all the pins on the LCD and that these connect to the PCB. Make sure there are no solder bridges between connections.

Long-range DAB+ reception

I am thinking about building the long-range DAB antenna as described in the November 2015 issue. The problem is that I live in the Lithgow area at 930 metres above sea level. It's possible to receive a DAB+ signal in the Upper Blue Mountains; even one of the surrounding hills a 10-minute drive away picks up DAB+ with a small whip antenna but that's at 1100 metres above sea level (Hassans Walls lookout).

However, perhaps I am expecting too much if I built and installed your antenna to pull the signal into a valley. Would there be any hope at all? I receive ABC jazz and SBS chill on TV. It will be interesting to read in future issues about readers pulling in DAB from long distances. (P. Y., via email).

● If you already have TV reception from Sydney (and not from a local translator) then there is every chance that you could also get DAB+ via the antenna we described.

Different transformers for amplifier module

I am enquiring about the supply voltage rails required to run the Ultra-LD Mk.3 Amplifier modules (SILICON CHIP, March, April & May 2012) as I wish to build a power amplifier to accompany my Studio Series preamplifier (SILICON CHIP, October & November 2005). They are listed on the Altronics website as a complete amplifier kit and as individual modules – they call for a 40V split rail supply courtesy of a 300VA 40V toroidal transformer (one per module) which they no longer stock.

With that in mind they sell a 35V, 45V and 50V models. Will the power supply PCB and more importantly the amplifier modules tolerate a higher/lower supply voltage without damage? (S. D., via email).

● No damage will result from using the lower-rated transformer and no circuit changes are required. You can also run the amplifier modules with the higher-rated 45V + 45V CT transformer, provided you are not driving 4-ohm loads. That would run the output transistors too close to second breakdown, which can be inferred from the load-line diagrams on page 32 of the October 2015 issue. A 50V + 50V transformer will provide too high a voltage.

With a 45V + 45V transformer, you will also be running the electrolytic capacitors in the power supply at very close to their voltage ratings, depend-

ing on the mains voltage fluctuations in your area.

By the way, Altronics have indicated that they will be supplying kits for the Mk.4 version of this amplifier, so perhaps they are not discontinuing the specified power transformer.

We can supply back issues or copies of any article that we have published in the past. Just go to our on-line shop.

GMT/UTC time on LED Clock

Greetings from the other side of the globe – I hope the weather there is better than here!

Seriously, I'm going to build the GPS High-Visibility LED Clock described by Nicholas Vinen in the December 2015 & January 2016 issues, for use in an amateur radio station "shack". My main requirement is that I be able to run the clock in GMT/UTC time permanently, ie, no change to Daylight Saving etc.

Can this be achieved with this design? I hope so. However, if not it will still be a decent clock on the wall. (R. P., via email).

● Yes you can certainly run the GPS clock in GMT/UTC time. It's simply a matter of setting the time zone manually to "EU IS". This is the time zone for Iceland which is the same as GMT/UTC, with no daylight savings in effect.

90V 150W supply wanted

Have you designed a circuit for a 90V 150W power supply? About 18 months ago I bought a new metal milling machine. It has a power drive on the table but it got a very large surge (about 50V) when the power station started another generator for the Blackwood Cole mine to move a drag-line scoop.

We are close to the power station and we get the full blast of power when they first turn the extra generator on, ie, before the mine switches the drag-line on. So the 90V DC motor in my milling machine does not work any more. As a result, I now have a safety regulator in the 230VAC line to save my machinery from the same thing happening again.

The power station will not pay for any repairs and say that I should have had the protection in place before it happened. Now I am looking for a power supply to run the table on my mill. The October 2015 issue of SILICON CHIP has a power supply for the Ultra-LD amplifier and I was wondering if it would do the job with the specified 45V transformer but only using the top half and not the 15V-0-15V part. (A. P., via email).

● Your 90V motor probably does not need filtered DC. In that case, the simplest approach would be to take the 90V AC from the transformer, feed it to a full-wave bridge rectifier and feed the rectified but unfiltered DC direct to the motor.

Calibration Problem With The High Voltage Probe

I'm trying to calibrate the High Voltage Probe for scopes from the January 2015 issue. It appears that I have a problem with either the offset adjustment or IC2a's output since I have a constant -4.02V at CON3. By adjusting the offset, it does vary a little but I am unable to adjust to 0V as per the instructions in the calibrations procedure.

It is possible to measure and adjust the offset so that the voltage between CON3 GND and either V2+ or V2- is exactly half of the battery2 voltage. So that does appear to work. The Gain Calibrate has little or no effect when moving the pot from one extreme to the other. Could you please supply some pointers as to what is going wrong and how to correct this error? (P. V., via email).

● It's hard to say exactly what is causing your problem but from your description of the symptoms, it sounds as if the output photodiode of OPTO1 is effectively open-circuited. This may not be due to a faulty HCNR201 but perhaps an accidental 'dry joint' in the connection to either pin 5 or pin 6.

We would therefore suggest that you check these solder joints before taking the more drastic and costly step of replacing the HCNR201.

Understanding how a loudspeaker works

For most of my adult life I have thought that I thoroughly understood how a moving coil speaker worked, and that was that the cone was moved back and forth solely by the magnetic force induced in the voice coil by the current driven though it by the amplifier's output voltage. The chain of events would therefore be that the amplifier voltage fluctuates up and down following the signal waveform, which in turn produces a fluctuating current in the voice coil, which in turn produces a fluctuating magnetic force in the voice coil, which then pushes and pulls the voice coil back and forth.

However, after some reflection on the details, it seems that I was wrong and that the motion of the cone is produced not by one force (ie, the magnetic force of the voice coil) but by two forces: (1) the magnetic force from the voice coil and (2) the spring force of the speaker suspension. The two form a kind of push-pull tug of war and it is this combination of two forces working in opposition to each other which controls the movement of the cone.

I realised this one day when I was reflecting on how a speaker would respond to the signal voltage from an amplifier putting out a simple sinewave. I straight away encountered two major problems. First, during the first quarter of the cycle, when the output voltage reaches it maximum value at the peak of the wave, the voice coil is supposed to have reached its maximum excursion and stopped moving. But why would the voice coil stop moving when the driving voltage is present and at its maximum value?

Then, during the second quarter of the cycle, the voice coil is required to reverse direction and begin moving back towards its rest position, yet although the output voltage from the amplifier is declining in value towards the zero level, it has the same polarity as it did during the first quarter of the wave and so should still be pushing the voice coil, not pulling it.

During the third quarter of the wave, the output voltage will have reversed polarity and so will be pulling at the cone but not now. Why is the voice coil moving back when the output voltage is surely pushing it in the other direction?

The obvious answer to these questions is that it is the speaker suspension, in the form of the spider and the outer surround, that moves the voice coil, using potential energy stored in it during the outward quarter of the wave,

Notes & Errata

High Visibility 6-Digit LED GPS Clock, December 2015 & January 2016: the parts list in the December issue should read:

9 BC547 (Q1-Q9)
10 BC337 (Q10-Q19)

These type numbers were transposed in the original parts list but were correct in Fig.1 & Fig.2. Note also that Fig.1 should show R8 as 68Ω and the label on Fig.2 should read Q20-Q26 for the MPSA13 transistors (not Q20-Q16).

The following additional notes also apply:
(1) To calibrate the 32kHz crystal, set the XTAL menu option to between -512 (260ppm slower than default) and +511 (260ppm faster). This is adjusted automatically when a GPS module with a 1pps output is used.
(2) When the alarm goes off, use a long (1s+) press of either pushbutton, or a second press of the Escape button on the remote to cancel it altogether. A short/single press will simply activate the snooze function.
(3) Maximum alarm duration has been extended to up to 15 minutes with a default of 10 seconds.
(4) The unit can show the day of the week. Simply activate the date display function, then press the same button again.
(5) A new menu item, "GPSLCK", has been added to the options menu. If set to "IGNORE", the unit will use GPS time even if the satellite fix is not perfect. This will allow the unit to work in marginal signal areas although time accuracy may not be quite as good.
(6) A new brightness menu item, "CUR RD", shows the minimum/current/maximum raw LDR readings in 8-bit hexadecimal notation. The fourth digit decimal point lights when the data is going to be saved to flash memory and goes out once it's saved. This can be used to troubleshoot the autodim function.

and not the magnetic force alone as I had formerly believed. So the magnetic force of the voice coil is only responsible for moving the cone outward from the rest position, and it is the suspension "spring" which is responsible for moving it back to the rest position.

It all seems rather obvious to me now but it seems odd that this is never explained in detail in most documentation I have read. The speaker's spider is usually referred to as providing a centring action, which I assumed just meant bringing the cone to a central position when the speaker is not being used. I never realised how important a function this spring performed until now.

If my new understanding of how the dynamic drive works is correct, and I believe it is, it shows that the linearity of the drive suspension is critical in terms of the distortion performance of the driver. No matter how linear the driving amplifier is, it is only responsible for half of the driving force applied to the cone – the suspension is responsible for the other half.

I wonder, is it me being exceptionally dumb and missing the obvious, or are other people unaware of the exact details of how a moving coil driver works? Or have I got it all completely wrong? (P. T., Casula, NSW).

● It is true that the suspension system does damp the cone motion and does provide some restoring force, so that the cone returns to its "centre" position in the absence of any voltage across the voice coil.

However, the suspension is designed to be as linear as possible so that the damping and "restoring force" is equal for forward and backward excursions of the cone. It is not a "push-pull tug of war" as you postulate.

In an ideal system, we could ignore the effect of the suspension on the basis that it is only there to "suspend" the voice coil over the magnet pole piece.

In fact, what happens is that the driving amplifier is a very low impedance voltage source (or it should be) which has very tight control over the speaker excursion at any time. So if you apply a sinewave signal, there is no tendency for the coil to over-travel and its motion is a very good analogue of the input signal.

Consider what would happen if there was a tendency for the voice coil to over-shoot (and there always is, in fact). This additional motion would induce an equivalent voltage in the voice coil and this extraneous signal would immediately be damped (think of it as being short-circuited) by the very low impedance of the driving amplifier. That is why it is most important, in a hifi system, to have very low resistance loudspeaker connecting leads. Otherwise the "damping factor" of the amplifier is reduced.

The "electronic damping" works in all modes, forcing the cone to follow the signal voltage. If the cone tends to lead or lag the signal, there will be an error voltage which will be heavily damped by the amplifier's very low impedance. The current that will flow in the voice coil, due to this damping of the error voltage, will force the cone back to the correct position.

Another point to be considered is that the current in the voice coil is not necessarily in phase with the driving voltage; the load present by a loudspeaker is inherently inductive, with an impedance which rises with frequency. Therefore you cannot simply think that the current flowing in the voice coil following the peak of a sinewave is simply "declining in value towards the zero level" and that it "has the same polarity as it did during the first quarter of the wave and so should still be pushing the voice coil, not pulling it". In fact, the current will always lag the voltage in a purely inductive load and that complicates the picture.

Finally, consider that the air trapped in the speaker box also tends to modify the motion of the cone, damping it more for reverse excursions than for forward motion. Again, this is where the amplifier is supposed to maintain tight control over the motion of the cone and stop it responding to these external non-linearities.

Ultimately, hifi amplifiers and loudspeakers do a remarkable job of turning electrical signals into analogous acoustic waveforms.

Currawong valve amplifier current

I have completed building the Currawong valve amplifier and have tested the unit for frequency response and also played some music from my iPod. The sound is very good.

However, after installing the plexiglass cover I noticed that the 330Ω 5W resistors which I had soldered leaving the 5mm gap suggested were flush against the PCB. The problem is that

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Ask SILICON CHIP

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they are running very hot and the heat melts the solder.

The HT voltage that feeds the valve plate was 282V and the cathode voltage was 47V. I double-checked all the components around the circuit and they are correct. Would you be able to advise me what the problem might be? (M. M., via email).

- 47V sounds like a very high cathode voltage; it's designed to run at about 22V – see the circuit diagram on page 31 of the November 2014 issue.

Assuming that they are 330Ω as specified, those resistors would be dissipating around 7W so it's not surprising that they're overheating.

Could it be that the two small wire links next to LK4 and LK5 are missing from the PCB? These connect the 6L6s' grid bias to GND. If the grid bias is floating, that could explain the high plate current. The only other explanation we can think is that you've used slightly different valves which have a different grid bias requirement.

If you're still not sure what's going on, check the voltage on pin 5 of the 6L6 sockets (ie, the grid) which connects to one end of the 10kΩ bias resistor between the 6L6s and the 12AX7s. This should have a DC potential of 0V relative to a convenient ground point (eg, valve socket mounting screws).

If everything seems correct, you could increase the 330Ω 5W resistors to say 680Ω 5W to reduce the operating current to a safe level however they will still be dissipating more than the circuit was designed for due to the higher cathode voltage. SC

Next Issue

The March 2016 issue of SILICON CHIP is due on sale in newsagents by Monday 29th February. Expect postal delivery of subscription copies in Australia between February 29th and March 5th.

Serviceman's Log

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going around in circles for an hour, I decided to replace all the electrolytic capacitors since these devices are notoriously unreliable once they have aged. There weren't many so it was a cost-effective way to hopefully make some progress.

Replacing these capacitors actually seemed to make a bit of a difference, so I packed up and returned to the glasshouse. However, I wasn't convinced that I'd found the fault, so I took the precaution of taking the signal tracer, an oscilloscope and a floodlight along with me, just in case.

After reconnecting the module and turning on the power, I was dismayed to discover that nothing had changed! I listened in with my signal tracer and again there was lots of noise but it was now quite loud – much louder than at my workshop. It seemed to be everywhere, even on the supply rails, and then I had a light-bulb moment!

The nearer I got to the battery with the signal tracer, the louder the noise became. I put the tracer aside, grabbed my digital voltmeter and checked the battery voltage once again. This time though, I held the meter there long enough to see that the battery voltage, now sitting at 46V, was fluctuating minutely. I then went from cell to cell with the voltmeter and each one read a nominal 2V until I got to about cell number 20 (yes, I had started at the wrong end). This cell had a reverse voltage on it and it was fluctuating wildly.

In fact, it was producing enough noise to break through the filtered supply rails and regulators of the control module and create havoc. Since the cell was effectively dead, I bypassed it with a jumper cable and everything sprang to life. The solenoids worked as they should and the rear wheels accelerated smoothly.

When I looked inside the faulty cell, I could see that the plates were quite distorted and almost corroded away. I made up a more permanent link to bypass the dead cell and advised the "Duck's" driver that doing so would put more load on the other cells and that they would probably have to have the lot replaced one day soon.

My guess is that it would cost at least $2000 for a new bank of batteries so I was happy that I had at least given them time to consider whether to spend that money on a new heart or to retire "The Duck" when it eventually broke down again. I also told the maintenance man not to leave the charger on for extended periods and to carefully monitor the state of charge.

And the clue I had missed right at the beginning? Having unplugged the charger when I first looked at "The Duck", the freshly-charged battery should have measured at least 50V and probably as much as 56V; certainly not 48V. The dead cell was not only not contributing its normal 2V but because it was negatively charged, it was subtracting that amount from the overall voltage.

There is a well known adage in the industry that I had failed to apply – always thoroughly check the power supply before anything else! A bad power supply can be the root of so many problems. **SC**

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